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VOLUME XXXI

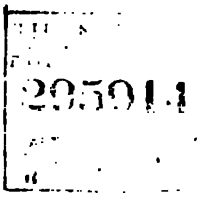
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CONTENTS.

JANUARY NUMBER.

SKETCH OF THE LIFE AND WORK OF THE LATE A. R. C. SELWYN, C.M.G., LL.D., F.R.S, F.G.S., etc., Director of the Geological Survey of Canada from 1869 to 1894. [Portrait.] *H. M. Ami*, 1

ON RHOMBOPORA LEPIDODENDROIDES. *Meek*. [Plate II.] *G. E. Condra* 22

VALLEY LOESS AND THE FOSSIL MAN OF LANSING, KANSAS. *Warren Upham*..... 25

NOETLING ON THE MORPHOLOGY OF THE PELECYPODS. [Plate III.] *R. Ruedemann*..... 34

NOTE ON THE WEST INDIAN ERUPTIONS OF 1902. *G. C. Curtis*.... 40

MINERALS OBSERVED ON BURIED CHINESE COINS OF THE SEVENTH CENTURY. *A. F. Rogers*..... 43

AN ERRATIC BOWLDER FROM THE COAL MEASURES OF TENNESSEE. *S. W. McCallie*..... 46

GEOLOGICAL AGE OF THE WEST INDIAN VOLCANIC FORMATIONS. *J. W. Spencer*..... 48

EDITORIAL COMMENT.

The Diamond mines of South Africa..... 51

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Om Sularpsbackens Dalgang. *J. C. Moberg*..... 53

Contributions to the Petrography of the John Day basin. *Frank C. Calkins*..... 54

Maryland Geological Survey, vol. IV. *W. B. Clark*..... 54

Les Roches volcaniques de la Martinique. *A. Lacroix*..... 55

MONTHLY AUTHOR'S CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE, ... 59

CORRESPONDENCE.

Apatite crystals, Antwerp, New York. *Nicholas Knight*..... 62

Fall Excursions of the Geological Department, Columbia University. *H. W. Shimer*,..... 62

PERSONAL AND SCIENTIFIC NEWS.

Chicago Academy of Sciences, 64; Geological Society of Washington, 64; Bath Furnace Meteorite, 64 J. W. Spencer, 65; Am. Inst. Min. Engineers, 65; New Mexico Academy of Sciences, 65; The late meetings of the Geological Society and of the American Association for the Advancement of Science at Washington..... 66

FEBRUARY NUMBER.

GEOLOGY OF THE JEMEZ-ALBUQUERQUE REGION, NEW MEXICO. *A. B. Reagan.* [Plates IV-XII.] 67
MORSE ON LIVING BRACHIOPODS. *Charles Schuchert*..... 112
TIMBER LINES. *I. C. Russell*..... 121
REVIEW OF RECENT GEOLOGICAL LITERATURE.
Report of the State Geologist on the mineral industries and geology of certain areas of Vermont. *Geo. H. Perkins*..... 122
Magnetic declination tables and isogonic charts for 1902, and principal facts relating to the earth's magnetism. *L. A. Bauer*, 123
Iowa Geological Survey, Vol. XII, 1901, with accompanying papers. *S. Calvin* and *A. G. Leonard*..... 124
A system of glacier-lakes in the Cleveland Hills. *Percy Fry Kendall* 124
MONTHLY AUTHOR'S CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE 125
PERSONAL AND SCIENTIFIC NEWS. 127
Geological Society of Washington, 128; Medal awards by the Geological Society of London, 129; Wisconsin Academy of Science, Arts and Letters, 129; Encouragement of mining in the new Mexican School of Mines..... 129

MARCH NUMBER.

THE I. H. HARRIS COLLECTION OF INVERTEBRATE FOSSILS IN THE UNITED STATES NATIONAL MUSEUM. [Portrait.] *Charles Schuchert* 131
BLOCK MOUNTAINS IN MEXICO. [Plate XII.] *Douglas Wilson Johnson* 135
SOME EVIDENCE OF TWO GLACIAL STAGES IN THE KLAMATH MOUNTAINS IN CALIFORNIA. *Oscar H. Hershey*..... 139
A NEWLY-FOUND METEORITE FROM MOUNT VERNON, CHRISTIAN COUNTY, KENTUCKY. *Geo. P. Merrill*..... 156
THE MARL-LOESS OF THE LOWER WABASH VALLEY. *M. L. Fuller* and *F. G. Clapp*..... 158
AMES KNOB, NORTH HAVEN, MAINE; A SEASIDE NOTE. *Bailey Willis* 159
ON THE MANLIUS FORMATION OF NEW YORK. *Charles Schuchert*, 160
EDITORIAL COMMENT.
A New Building for the United States National Museum..... 178
REVIEW OF RECENT GEOLOGICAL LITERATURE.
Alphabetical cross-reference catalogue of all the publications of Edward Drinker Cope from 1850 to 1897. *Persifor Frazer*.. 180
Recent geologic work in Franklin and St. Lawrence counties [New York]. *H. P. Cushing*..... 180
Les analyses *en bloc et leur* interpretation. *F. Fouque*..... 181

Les Roches alcalines caracterisant la Province petrographique d'Ampasindava. *A. Lacroix*..... 183
Index animalium. *C. D. Sherborn*..... 184
Das Sonnwendgebirge im Unterinnthal, ein Typus alpinien Gebirgsbaues. *Dr. F. Wahner*..... 185
On the lakes of southeastern Wisconsin. *N. M. Fenneman*.... 185
The origin of certain place names in the United States. *Henry Gannett* 186
Bornholms Paradoxideslag og deres Fauna. *Karl A. Gronwell* 186
MONTHLY AUTHOR'S CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE 188
PERSONAL AND SCIENTIFIC NEWS.
The Clayton Stone Axe, 193; Thomas Crowder Chamberlin, 193; American Museum of Natural History, 193; A new Division of the United States Geological Survey..... 194

APRIL NUMBER.

THE LIFE AND WORK OF PROFESSOR CHARLES M. HALL. [Portrait.] *Warren Upham*..... 195
PROFESSOR JAECKEL'S THESIS ON THE MODE OF EXISTENCE OF ORTHOCERAS AND OTHER CEPHALOPODS. *Rudolf Ruedemann*.... 199
WITH ANNOTATIONS. *John M. Clarke*..... 216
THE CENTRAL OHIO NATURAL GAS FIELD. [Plate XIV.] *J. A. Bownocker* 218
STRUCTURE OF THE SOUTHERN PORTION OF THE KLAMATH MOUNTAINS, CALIFORNIA. *Oscar H. Hershey*..... 231
SOME RESULTS OF THE LATE MINNESOTA GEOLOGICAL SURVEY. *N. H. Winchell*..... 246
REVIEW OF RECENT GEOLOGICAL LITERATURE.
Esquisse stratigraphique et petrographique du Bassin de la Tafna. *Louis Gentil*..... 253
Ellensburg (Washington) folio. *George O. Smith*..... 255
United States Geological Survey, folios 81, 82, 83. *Messrs. Alden, Campbell, Fuller* and *Ashley*..... 255
Report on the Geology of Louisiana, containing special papers by different authors. *Gilbert D. Harris*, State Geologist, *A. C. Veatch, J. A. A. Pacheco*..... 256
Notes on Cambrian faunas. *G. F. Matthew*, with description of a new species of Metoptoma..... 256
Topographic development of the Klamath mountains. *J. S. Diller* 257
MONTHLY AUTHOR'S CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE 259
PERSONAL AND SCIENTIFIC NEWS.
Professors Pumpelly and W. M. Davis, 262; Extinct Bison from Alaska, 262; The Geological department of Harvard University, 262; A fossil Mammoth's tooth in Iowa..... 262

MAY NUMBER.

THE PLEISTOCENE GEOLOGY OF THE CONCANNON FARM, NEAR LANSING, KANSAS. *N. H. Winchell.* [Plate XV-XVIII.]..... 263
NOTE ON TITANIFEROUS PYROXENE. *Alexander N. Winchell*..... 309
BASIN-RANGE STRUCTURE IN THE DEATH VALLEY REGION OF SOUTHEASTERN CALIFORNIA. *M. R. Campbell*..... 311
EDITORIAL COMMENT.
How long ago was America peopled?..... 312
REVIEW OF RECENT GEOLOGICAL LITERATURE.
Schmalenseeia amphionura en ny trilobit-typ. *J. C. Moberg*, 316
The Glacial Geology of New Jersey. *R. D. Salisbury*..... 316
MONTHLY AUTHOR'S CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE 319
PERSONAL AND SCIENTIFIC NEWS.
Geological Survey of Washington, 325; Am. Phil. Society, 325; The Tetrahedral Theory, 325; Elephant, Bison and Man in Eastern Washington, 325; Mining in Colorado, 326; Harvard Summer School scholarships, 326; Ellsworth Huntington, 326

JUNE NUMBER.

JOHN WESLEY POWELL. *Geo. P. Merrill* . [Portrait.]..... 327
THE RICHMOND GROUP ALONG THE WESTERN SIDE OF THE CINCINNATI ANTICLINE IN INDIANA AND KENTUCKY. *Aug. F. Foerste.* [Plates XX-XXII.]..... 333
AN OLD PLATTE CHANNEL. *G. E. Condra.* [Illustrated.]..... 361
RELATIVE AGE OF THE LANCE CREEK (CERATOPS) BEDS OF CONVERSE CO., WYOMING, THE JUDITH RIVER BEDS OF MONTANA AND THE BELLY RIVER BEDS OF CANADA. *J. B. Hatcher*.... 369
THE DETERMINATION OF THE FELDSPARS IN THIN SECTION. *J. E. Spurr* 376
REVIEW OF RECENT GEOLOGICAL LITERATURE.
The cause of the Glacial Period, being a Resumé and Discussion of the Current Theories to account for the Phenomena of the Drift, with a New Theory by the Author. *H. L. True*, 384
Existence du Cretace inferieur en argolidt Grece—Existence du Jurassique sup. et de l'infra-cretace dans l'isle de Crete, etc., etc. *L. Cayeux*..... 386
MONTHLY AUTHOR'S CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE 386
CORRESPONDENCE.
The Rock Name Amorthosyte. *Carl Fred Kolderup*..... 393
PERSONAL AND SCIENTIFIC NEWS.
Proposed Topographical Map of Michigan, 305; New Mexico School of Mines, 305; Department of Geology of the University of Wisconsin, 306; United States Geological Survey, 306; American Institute Mining Engineers, 307; Wisconsin Geological Survey, 307; International Congress of Geologists, 308; National Academy of Sciences..... 398

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AMERICAN GEOLOGIST.

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SKETCH OF THE LIFE AND WORK OF THE LATE DR. A. R. C. SELWYN, C. M. G., LL. D., F. R. S., F. G. S., ETC., DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA FROM 1869 TO 1894.

By H. M. AMI of the Geological Survey of Canada.

WITH PORTRAIT, PLATE I.

Dr. A. R. C. Selwyn, C.M.G., LL.D., F.R.S., F.G.S., for twenty-five years the eminent Director of the Geological Survey of Canada, (1869-1894) and one of the original Fellows of the Royal Society of Canada, died in Vancouver, British Columbia, on Sunday, the 19th day of October, 1902, the result of a stroke of paralysis.

His death was not altogether unexpected, but it removes from our midst one of the most energetic and active personalities in the field of geological work and science in North America, Selwyn did much to advance the practical or economic side as well as the highest and fundamental principles on which geology is based. His coming to America marks an era in the progress of geological thought and investigation inasmuch as he brought with him the practical experience of nearly thirty years of work on the geological surveys of Great Britain and Australia, more especially in the early Palæozoics and the igneous masses around which so many minerals of economic value occur, the nature of which he emphasized strongly, and to which he was one of the first to draw special attention and to interpret in their right light. During all the years that he spent in Canada he was diligent in mapping or having mapped the volcanic rocks of the various regions examined.

It is interesting to note that Prin. Dresser's* paper giving the result of his studies on the petrography of the Eastern Townships of the province of Quebec, issued just at the time of Dr. Selwyn's death, confirms in a marked degree the anticline theory of the structure of the Sutton mountain and other volcanic belts of that part of Canada.

He was the son of the late reverend Townsend Selwyn, canon of Gloucester cathedral, by his wife, Charlotte Sophia, daughter of Lord George Murray, bishop of St. David's, and grand-daughter of John the fourth duke of Athol.

He was born at Kilmington, Somersetshire, England, on the 28th day of July 1828.

His studies were carried on, first at home under private tutors, and later he completed his education in Switzerland.

At the early age of twenty-one (1845) he was appointed to a position on the Geological Survey of Great Britain under Sir Henry de la Bèche. His earliest work on the British survey was under the immediate supervision of no less distinguished a geologist than A. C. Ramsay. He was one of that contingent of stratigraphical geologists under Ramsay who did so much to lay down the fundamental and carefully traced lines separating the various geological formations in that wonderful compendium of geology that England has proved to be, all in a nutshell. The others on the staff with Selwyn were, W. T. Aveline, Trevor E. James, D. H. Williams, H. W. Bristow, and W. H. Baily. Edward Forbes was the palaeontologist, W. W. Smythe, the mining geologist, Sir Joseph Hooker was the botanist, Dr. Lyon (later Sir Lyon) Playfair, the chemist: while Richard Phillips was in charge of the laboratory and museum: with Robert Hunt as keeper of the mining records. Mr. C. R. Bone was employed as artist and C. P. Gibbs as collector of fossils.

Under chiefs like Sir Henry de la Bèche and A. C. Ramsay, Selwyn made rapid strides in the science of geology for which he had acquired a taste during his stay in Switzerland.

He remained attached to the Geological Survey of Great Britain until 1852 and devoted his energies to elucidating and mapping the difficult and intricate structure of the Palaeozoics of North Wales and adjacent portions of western England.

* A petrographical contribution to the Geology of the eastern townships of the Province of Quebec." *Amer. Jour. Sci.*, 4th series, vol. xiii, No. 70, pp. 43-48. July, 1902. New Haven.

He is credited with no less than sixteen geological maps prepared either entirely by himself, or, in conjunction with, his chief, Sir A. C. Ramsay, or the Director-General himself, or again, with such well-known men on the geological staff as Ed. Hull, W. T. Aveline, W. W. Smythe, J. Phillips, H. B. Howell and his particular friend and colleague J. B. Jukes.

The geological sheets or maps of Leominster, Montgomery, Market Drayton, Harlech, Banger, Bardsey and Machynlleth are ascribed in part or in whole to the subject of this brief sketch.

It was during his field work in Wales that Selwyn discovered the unconformity between the lowest Cambrian and the older series of schists underneath. In this classic country of the Welsh succession, Selwyn and Ramsay worked together and of one of those "Councils" on the Shropshire sheets the latter wrote at the time in his field note-book:—"Held a council with Selwyn on the Shropshire sheets, etc. his work there and here (North Wales) is the perfection of beauty." "One of the most striking sections of the whole series of sections published by the Geological Survey," writes Sir Archibald Geikie later, "runs from the top of Snowdon parallel with the Llanberis valley to the Menai straits at Llanfair, whence it was afterwards continued across Anglesey. On the other side it was prolonged south-eastwards into the country mapped by Selwyn, and was carried by him into Merionethshire, across Cynicht, Moel Wyn and Aran Moddwy, and was continued by Aveline across Montgomeryshire." Sir Archibald adds:—"The geological structure is portrayed by Ramsay and Selwyn with a boldness and vigour, and at the same time with an artistic feeling, which had hardly been equalled in geological section-drawing."

In 1845 Selwyn worked out the complicated geology of the volcanic distric of Cader Idris in North Wales: the summer of 1846 he was engaged in mapping out the rock formations in the Dolgelly region, whilst Aveline was tracing the boundaries of the Silurian series from Llanbrynmair eastward to the Church Stretton and the Longmynd. Ramsay accompanied Selwyn and records:— "Glorious days and glorious scenery, out with Selwyn along the front of the Cader Cliffs." He adds:— "Selwyn's work good." Testimony from such

a high source must have been very gratifying to young Selwyn who rose step by step and advanced in favour amongst his colleagues and superiors.

In August 1847 his work lay in the direction of Festiniog in which he was associated with Ramsay, Playfair, Jukes and Gibbs. This difficult region offered many problems of economic as well as of geological interest and the careful results obtained were discussed on the ground and incorporated in the classic maps since prepared. The same year Selwyn was at Capel Curig, Jukes was transferred to the South Stratfordshire coalfield and in writing to Ramsay of Selwyn's work Jukes says:— "It so happens that the last time I saw Selwyn, we were mutually wishing that you would send us both into Stratfordshire together." After leaving Wales however the subject of this sketch carried on his investigations in portions of Shropshire as far north as the Triassic outline of Prees.

The friendship that had arisen between Jukes and Selwyn in their joint work in Wales grew as years went on; and in 1848 they communicated a paper to the Geological Society of London giving the results of their investigations in North Wales.*

This friendship was kept well alive during all the years Dr. Selwyn was director of the Canadian Geological Survey, as many of his colleagues of those years can testify, for, whenever difficult points in the stratigraphy and palæontology of different portions of Canada arose and were discussed in a forceful and masterly but always courteous and gentlemanly manner, he was wont to quote the words of his friend Jukes as follows:— "As my friend Jukes always said, 'If the palaeontology does not agree with the stratigraphy, so much the worse for the fossils.'"

In 1848 Selwyn's work took him in the Port Madoc and Dolgelly districts of North Wales. There he and Ramsay pursued their work amid the glorious scenery surrounding the heights of Snowdon and the magnificent and bedecked viewpoints of the foot ranges. In October of that year considerable discussion arose regarding the structure and succession at Glaslyn, and thither Sir Henry de la Bèche, Edward

* A. R. Selwyn and J. B. Jukes, "Sketch of the structure of the country extending from Cader Idris to Moel Siabod, North Wales." *Quarterly Journal, Geological Society, London*, vol. vi, pp. 300-302, 1848.

Forbes and also Ramsay went, to determine if possible the points in question and to settle them on the spot. Selwyn was at work on the side of Crib-goch, on the top of a crag, and his well-known shrill shout soon reached Ramsay who discovered him, and later in the day they all joined forces and compared notes and finally put matters straight at Glaslyn.

Many a knotty problem in Cambrian geology was discussed by these masters of geology in the lovely vale of Beddgelert where Selwyn was located, or at Llanberis which Ramsay and Forbes made their headquarters. In 1849 Selwyn completed the survey of the rock formations lying between the Snowdon range on the north and Ffestiniog and Tremadoc on the south, and turned his attention to the Lleyn peninsula from Pylheli. At Aber, and as late as December of the same year, Ramsay and Jukes joined Selwyn and had a very pleasant meeting. The following spring saw the same trio at Merchlyn in North Wales, where many conferences were held on critical points touching sundry lines to be drawn as boundaries between different geological formations.

Selwyn was an alpinist or mountain climber of no mean order. From the experience gained when in the Swiss Alps it was a pleasure and no effort for him to climb the peaks and scale the heights of the Snowdon range, not to speak of the numerous crags of the region surrounding the same which he traversed in his geological explorations. Later in life, in the Mount Serle region of South Australia, and in the district surrounding mount Alexander as well as in the Canadian Rockies he was a most intrepid climber. Ramsay states that he was "out on the hills with Selwyn, one day (4th of May 1850) as far as the cliffs under Carned Llewelyn and down by Melynllyn and Llyndulyn." Besides good work done on that day "Selwyn executed a most perilous feat of cliff-climbing: a slip and he would have been slain." Later while in Canada and during the Rocky mountain excursion in connection with the meeting of the British Association for the Advancement of Science in 1884, Dr. Selwyn had a most narrow escape for his life at the mouth of the tunnel near the base of mount Stephen. His keen eye detected the loosening mass of limestone above; his agility and wonderful presence of mind led him to jump on adjoining timbers thus saving his life on this occasion.

In the closing months of 1850, after completing the North Wales sections and maps and putting on the final touches in conjunction with Sir Andrew Ramsay, Selwyn was entrusted with field work in Anglesey where they crossed and carried on the work begun by Sir Henry de la Bèche. It was in Anglesey that Selwyn detected the unconformity of the lowest Cambrian strata upon an older Pre-Cambrian series of schists. In this view Sir Henry supported Selwyn, but Ramsay on this occasion differed, so that when the map was published no Pre-Cambrian rocks were shown. In the following year (1851) Selwyn was back at Dolgelly, checking a number of points and investigating critical parts of the complex geological structure.

Selwyn was of a bright and cheery disposition and besides the happy re-unions held in London on the part of the "Royal Hammerers" as they styled themselves, Ramsay, Selwyn, Aveline, Jukes and other geologists of Wales along with their contemporaries, the annual dinners of the Survey were events in which a jolly time was spent: Ramsay in recording Selwyn's presence at the dinner held 15 January, 1851 says: "And Oh! wasn't it a jolly dinner!"

In 1852 before completing the whole task of mapping the regions examined by him in England and Wales, Selwyn took unto himself a wife, as had also many of his colleagues, marrying Matilda Charlotte, daughter of the Rev. Edward Selwyn, rector of Hemmington Abbotts, Hunts, and in the following year he was appointed by the Colonial Office director of the geological survey in the newly formed colony of Victoria, Australia, which had come into great prominence owing to its wonderful goldfields.

His training in the older Palaeozoics or Cambrian rocks of Wales was of special value to him in the new colony, and accordingly he set himself to the task of mapping out the gold bearing rocks and auriferous gravels of different ages, and in tracing their relations to other rocks of the district.

Here he had a field of work nearly twelve times greater than he had in Wales; Victoria, the smallest of the Australian Colonies, having an area of 87,884 square miles, whilst Wales has a total area of 7,378 square miles only.

In Australia Selwyn was ably assisted by Messrs. C. S. Wilkinson, H. Y. L. Brown, C. B. Brown, Robert Etheridge,

Jr., and other geologists. Besides an extensive series of geologically coloured maps of Victoria, and official reports, Selwyn prepared the following reports and papers bearing more especially upon the economic resources of Australasia:

"On the Geology and Mineralogy of Mount Alexander and the adjacent country lying between the rivers Loddon and Campaspe." *Quart. Jour. Geol. Soc., Vol. X, pp. 298-303. (1854)*, London.

"Report on the Geological Relations of some of the Coal seams of Van Diemen's Land, their probable extent, and relative economic value." *Van Diemen's Land Royal Society Papers, III, pp. 116-141, 1855-1859.*

"On the Geology of the Goldfields of Victoria." *Quart. Jour. Geol. Soc., Vol. XIV, pp. 533-38.* London, 1858. and *Geologist,* Vol. I. pp. 163-4. 1858.

"Notes on the Geology of Victoria." *Quart. Jour. Geol. Soc., Vol. XVI. pp. 145-50. 1860.*

Geological Notes of a journey in Australia from Cape Jervis to Mt. Serle," *Proc. Geogr. Soc., Vol. V, pp. 242-44. 1861.*

"Report on the Auriferous Drifts and Quartz-reefs of Victoria: observations as to the probable age of the Lower Gold Drifts." Published in Victoria, Australia, May 4th, 1866. Reprinted in the *Geological Magazine, Vol. III, pp.* 457-459. London, Eng., 1866.

While in Victoria he added much to the knowledge of the gold-bearing rocks of that colony and also aided in tracing the relation of the Miocene Tertiary strata so rich in Eocene Mollusca.

Among the interesting collections made by Dr. Selwyn in Victoria may be mentioned that now deposited in the museum of the Geological Society of London, Burlington House, consisting of Tertiary shells from the Murray river. He was continuously engaged as director of the Geological Survey of Victoria from 1852 to 1869, a period of nearly seventeen years, and he resigned when the legislature refused to vote the necessary funds to carry on the work.

Selwyn's Work in Canada.

It was on the first of December, 1869, that Selwyn took charge of the Geological Survey of Canada, which had from its inception in 1842 been carried on by Sir W. E. Logan. Selwyn had arrived in Canada in October of the same year; and vigorously set himself to the task of studying and revising the reports that had been received from the various assistants who included the following well-known Canadian geolo-

gists: Sir Wm. E. Logan, Edward Hartley, T. Sterry Hunt, Robert Bell, James Richardson, Charles Robb, and H. G. Vennor. Besides the above, Robert Barlow, Esquire, and his son Scott Barlow, had charge of the topographical and cartographical part of the survey, whilst Elkanah Billings was palaeontologist, with Messrs. Horace Smith and Thomas C. Weston as assistants, one an artist, the other in charge of museum work etc.

When Selwyn became director of the Geological Survey of Canada and deputy head of the same, the confederation of some of the British American provinces had only just been effected, and accordingly there was now open a much wider field of investigation than formerly. As one after another the different provinces and districts became part and parcel of the Dominion of Canada the work increased accordingly, and to such an extent that the staff of geologists and assistants had to be materially increased; and men had to be trained to pursue the good work of the old régime.

This period was one of great activity in the Canadian survey. The first copies of Logan's large "Map of the Geology of Canada and adjacent parts of the United States" prepared for the engraver by Robert Barlow, were received during the first month of Selwyn's administration from Edward Stanford, the publisher, Charing Cross, London.

As an instance of the remarkable activity and energy displayed by the second director of the Geological Survey of Canada at the outset of his career in Canada, it may be remarked that he not only proposed to the Hon. Joseph Howe the various points noted above but also presented the annual "Summary" report of the geological investigation made by the staff the previous year.

He further impressed upon the government the advisability of placing a special appropriation in the estimates of the year for the distribution of Logan's large map just received, submitting at the same time a list of public and educational institutions, libraries, etc., where the said map would do a great deal of good to Canada.

In 1870 he investigated the gold-fields of Nova Scotia and prepared an important report giving the result of his work there. (See "Report of Progress, Geol. Surv. Canada, 1870-71," pp. 352-82, Ottawa, 1870.)

In the following year, under special instruction from the Hon. Joseph Howe, he undertook an exploration in the remote province of British Columbia "On and in proximity to the several lines which will be explained by the engineering parties '(of which Mr. Fleming, now Sir Sandford Fleming was engineer in chief,)' and on one or the other of which the future Pacific railroad will be located." In the "Report of Progress" for 1871-72, is given an account of the results achieved during these explorations. The route selected by Selwyn took him from Hope on the Fraser *via* Fort Colville, the Kootenay river and the Columbia to Howse's pass, and afforded facilities for returning later by wagon-road 378 miles, from Cariboo to Yale. Not only the occurrence of coal-fields, gold-fields and other minerals of economic value, but the timber, soil, water-power, agricultural and numerous other features of special value and interest were also recorded, together with a systematic description of the various geological formations met with and their relations one to the other in the series from the oldest up.

Then in 1872 we find him journeying from lake Superior to Fort Garry, (now Winnipeg) and in the "Report of Progress" for 1872-73 we find no less than three special reports, on the silver mining localities on Thunder bay, on the geological investigations from Lake Superior to Fort Garry and on the Acadia iron-ore deposits. In the following "Report of Progress" he gives the result of his observations on the geological exploration in the North West Territories from Fort Garry to Rocky Mountain House. (loc., cit. pp. 17-62.)

In the following year Dr. Selwyn remained for the most part of the year in the office, attending to the numerous and onerous duties incumbent upon him and preparing for the work imposed upon him in connection with the Canadian exhibit at the Philadelphia "Centennial Exhibition" of 1876. In the "Report of Progress" for 1875-76 pp. 28-31, he gives the summary of personal explorations in British Columbia, and on pp. 31-69 presents his "Journal of the expedition through the Peace River pass." On pp. 292-93 he adds an important note on a boring made in 1875 on Swan river in the Territory now within the province of Manitoba. He also prepared a map of the region from Quesnel, British Columbia,

to the junction of the Peace and Smoky rivers. In 1876-77 (Report of Progress for those years) "Notes on the Quebec Group" appear, a subject to which he gave considerable attention, and in which he did much to separate from that series those rock formations which were of volcanic origin. In the report of 1877-78 pp. 1-15, further notes are given "On the stratigraphy of the Quebec Group" (of Logan) and older crystalline rocks of Canada. This is said to be one of the best attempts of systematic classification of the most ancient and difficult rock masses ever made. The following year's report (1878-79) Selwyn's work in the Eastern Townships and other portions of Quebec is given, and a "Note on the origin of granite treated as metamorphosed strata, not intrusions" occurs in the Report of Progress for 1879-80, pp. 5-6. The same report contains also an account of boring operations in the Souris River valley of the Manitoba (pp. 1-11A). On pp. 51-55A the fossil plants collected by Dr. A. R. C. Selwyn at Roche Percée and determined by Sir J. W. Dawson are recorded and described. His work on the Lake Superior region during the year 1882 is embodied in the report for 1880-82, pp. 16-17, together with a report on an exploration in Manitoba during the same year on the White Mud and Souris rivers.

"On the Geological nomenclature and colouring and notations of maps" forms the topic of an important contribution from his pen, pp. 47-51 of the "Report of Progress," for 1888, followed by additional notes on the geology of the southeastern portion of Quebec, pp. 1-7A; and followed later in the report by a note on the accuracy of the plan of the mouth of the Moose river surveyed by R. Bell in 1883-84, besides a summary of the work of Selwyn during 1883 on lake Superior, in the Souris Coal district, in Assiniboia and in the Cascade Coal basin of British Columbia.

Selwyn leaves behind him a career full of usefulness to the Empire. His work was truly of an imperial nature, for it extended not only into various portions of Great Britain but also to the distant colonies of the mother country, to the "Island Continent" of Australia and to the Dominion of Canada. for nearly eight years (1845-52) he laboured diligently in England and Wales, for seventeen years (1852-1869) he carried on geological investigations in Victoria, and spent twenty-

five years additional in Canada thus completing in December, 1894, half a century of active geological work. He was not a voluminous writer for publication, but he was an excellent letter writer. He never spared himself in attending to the numerous letters which the correspondence branch of the Geological Survey entailed. He did much to give the department the good name it has acquired, and for which it has been so favorably known as a bureau of exact information on a thousand and one things of special interest and value to prospectors and investors in all the provinces of the Dominion, as well as in some of the remotest corners of our country.

There is little doubt that the state of efficiency of the Canadian survey grew apace under Selwyn. Having had for many years closely associated with him as chief advisor and assistant the late and lamented Dr. George M. Dawson, Selwyn led the ship through thick and thin most successfully. It cannot be denied that it was under Dr. Selwyn's administration that the survey reached the hight of its success in carrying out the objects and aims for which it was instituted.

Nevertheless, it must not be understood that there were no difficulties to overcome, or swords to cross in the long period during which he was director.

Selwyn's aim from the start was to make the Geological Survey of Canada, an eminently practical Department, in which the records of mines and mineral statistics would be kept for the use and information of Parliament and the public. Accordingly, it is with satisfaction that we find him in the second month of his term of office (January 1870) busily engaged in organizing a branch of the geological survey for the purpose of collecting in a systematic way "Records of Mines and of Mining statistics of the production and consumption of Minerals in the Dominion." The decision he arrived at was published in the official "Canada Gazette" and Messrs. Edward Hartley and Prof. Robert Bell were requested to undertake the collection and arrangement of the returns made from year to year. The inadequacy of the buildings then at the disposal of the survey was a point on which Dr. Selwyn repeatedly dwelt, and a larger amount of the space necessary to the proper illustration and exhibition of the mineral resources and industries of the different provinces was repeatedly urged by him.

His first "Report" is addressed to the Hon. Joseph Howe, M.P., Secretary of State for the provinces, and in it Dr. Selwyn points out the practicability of the establishment of a School of Mines in connection with the Geological Survey.

The following passage taken from Dr. Selwyn's inaugural address as president of the section of geological and biological sciences, of the Royal Society of Canada, delivered May the 25th, 1882, gives an excellent idea of a high-minded spirit and love of the science to which he was devoting his life and energies. In dealing with general scientific work in new countries and the constant "struggle for life" which scientists have to encounter, he writes:—"In spite, however, of these difficulties Canadian geologists have succeeded in attaining and holding recognized and highly honorable positions in the scientific world. It is needless to dwell on the history and details of the struggle which has achieved this result and in which you all, with others now no more, have nobly shared. It behooves us, however, and especially the younger members of the corps, to remember that the fight is not ended, that, as in the past, so in the future, the struggle will have to be maintained. But if this society so auspiciously inaugurated, effects that much needed concentration, and consolidation of the efforts of the hitherto scattered combatants, uniting them in one solid phalanx, we may feel assured that the struggle of the future will be a far less arduous one than the struggle of the past. More especially will this be so if we never for a moment forget that the only object of scientific inquiry is truth, That the soul and life of this search in which we are all engaged consists in the fresh interchange of thoughts and the love of full and complete investigation, with fair and open discussion, unbiassed by and irrespective of all personal considerations and based not on theory but on carefully observed and honestly stated facts. Such evidence, treated in the spirit I have indicated, certainly will lead us to the truth, but we must always guard against confounding it, as has so often been done, with ingenious theory and dogmatic assertion, because these, however clever or eloquently supported they may be, are almost certain to lead us in a direction the very opposite to that in which it should be our aim to travel. For similar reasons partizanship, however commendable and necessary in the political

arena, should never be admitted to the domain of science. Bearing these principles in mind, and above all that unity is strength, I trust that the members of the geological section of the Canadian Royal Society will henceforth be brethren of the hammer not in name only but in very act and deed; that they will at all times cordially co-operate with and assist each other in friendly emulation in the work they have in hand, that of elucidating the geological history, physical and biological, of this great country in which the harvest, waiting to be gathered from the rocks, is so abundant but unfortunately the labourers as yet so few."

First and foremost Selwyn was a stratigrapical geologist and an able one. He was a firm believer in the field character exhibited by the various series of sedimentary strata in the succession of geological formations in the earth's crust and also by the volcanic materials.

He had a special attraction in the regions where the geological structure was complex and more especially was this the case as regards the eastern townships of Quebec, for, not only during his twenty-five years of office did he take an active part in the examination and elucidation of one of the most difficult and perplexing problems in geology and in the discussions attending the same, but even after his retirement he was wont to come back to the survey and to the other members of the staff would present his views in that bold and vigorous manner so characteristic of him. The volcanics of the eastern townships and their associated formations afforded an extensive field for discussion of the highest order. The results of his own field-work led him to interpret the geological structure of that portion of Canada in a manner hitherto unknown on this continent. In the Lake Superior region likewise Dr. Selwyn delighted in carrying on geological investigations whenever the duties of office would permit him to leave the desk for the field.

His keen interest in the "Quebec Group controversy" in which Logan, Billings, Hunt, Emmons, Sir Wm. Dawson, Hall, Walcott, Ford, Marcou and many others took a prominent part, was ever kept active by the fires arising in the discussion of the numerous knotty points in connection therewith. Selwyn's interpretation of the geological structure of the so-

called "Unfossiliferous Quebec Group" seemed a revelation to practical geologists and gave the key to the solution of at least one important side of the controversy, and he thus materially contributed to the advancement of our knowledge of that intricate field by separating the volcanic belts; and recognized the anticline structure which they exhibit in contradistinction to the synclinal which the ranges were for many years supposed to present.

Like his predecessor in office Dr. Selwyn was always a strong supporter of the Geological Survey Museum not only as an important factor in the interests of the country, but also as an educator. The wisdom of moving from Montreal to Ottawa during his term of office was very soon demonstrated in the numbers who registered and came to it from day to day. The inadequacy of the building and its total unfitness not only for geological work pertaining to the department, but also for exhibition purposes, were time and again emphasized by him and it is no doubt owing to his determination and energy in the direction of preparing plans for a national museum that practical steps have been taken towards the erection of a building worthy of the country.

In 1884 a committee of the House of Commons was appointed to investigate the work of the Geological Survey of Canada. The evidence of personal animus displayed by Selwyn's antagonists in the process of the investigation contrasted with the excellent work that was being done by the Geological Survey in past years and at the time of the investigation led the government to further strengthen the hands of the director and recommended the establishment of a division of mines and mineral statistics, much in the lines laid down by Dr. Selwyn himself in 1870, but which for reasons not stated had not been effectively carried out as expected.

Selwyn inlet in the Queen Charlotte islands.

Selwyn lake, Carr River, Ontario.

Selwyn river, Cranberry River, British Columbia, which enters the Fraser river below Tête Jaune cache, are names of places called after the subject of this sketch and serve to perpetuate his name in the geography of the country where his activities kept him for a quarter of a century.

Selwyn received many honors in his day. Besides occupying various official and responsible positions appertaining to his office as head of the Geological Survey of Canada in the different international exhibitions which entailed a great deal of executive ability and work, he was created a C. M. G. (companion of the Order of St. Michael and St. George) by Her Most Gracious Majesty Queen Victoria, who conferred the honor upon him in person, Selwyn having been summoned to appear at Windsor Castle during the summer of 1886. He was elected a fellow of the Royal Society of England, was one of the original fellows of the Royal Society of Canada, founded by the marquis of Lorne, now the duke of Argyle, and was elected to the presidency of that society in 1896.

He also received the medal of the "Acclimatization Society" of Melbourne, Australia, in 1881. He received the degree of doctor of laws (LL.D.) for his distinguished services in the field of geology and was president of the Natural History Society of Montreal in the days when the Canadian Survey was located in that city.

In preparing this account of the life and work of our late lamented "chief", the writer desires to acknowledge his indebtedness to Dr. Henry Woodward, F.R.S., etc. for his able article on Dr. Selwyn published in the February number of the *Geological Magazine* for 1899 as one of a series of original articles on "Eminent living Geologists." He quoted largely from this source; also from the list of publications issued by the Royal Societies of England and Canada, and from N. H. Darton's valuable "Index" of publications on the geology of North America, and to Monsieur Michel Mourlon's "Bibliographia Geologica."

In the office Selwyn was a strict disciplinarian. He loved order and system as well as courtesy and deference due to superior officers, such as is the custom in the old world. Neatness seemed to be one of his leading characteristics, and in the reports and work that he received from the staff he expected the same. The more stern and severe official side of his nature was in marked contrast with the sociable, amiable and chivalrous which characterized him in his own home; in private and in public gatherings he always strove and appeared to advantage.

He was tall and graceful, quick and alert, of a rather high-strung and nervous disposition, with a keen and observant eye, capable of grasping the situation at a glance in any emergency He was economical in his habits; and whilst he was not one of those who bestowed many encomiums nevertheless he duly appreciated work of high order.

Selwyn was an English scholar of rare ability. His writings both published and private are masterpieces of English composition, and the time and care that he bestowed upon the various reports and drafts of reports sent in for publication not only added to their value and elegance, but also to the labour devolved upon him; which work might well have been in part entrusted to an editorial staff had the appropriations allowed.

Amongst his chief works may be mentioned:—"The Dominion of Canada and Newfoundland" being Chapter II of Edward Sandford's "Compendium of Geography and Travel," a work after Hellwald's "Die Erde und ihre Völker" published in 1883; "Descriptive Sketch of the Geography and Geology of the Dominion of Canada to accompany the Wall Map of the Geology of Canada," No. 411, in 1884; Notes and Observations in the Goldfields of Quebec and Nova Scotia. Rep. Prog., Geol. Surv. Can., 1870-71, Montreal, 1872.

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Report on British Columbia. Geological Survey of Canada, Report of progress, 1871-72, pp. 16-72. Montreal. 1872. Including analyses by T. S. Hunt.

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Summary Report of Geological Investigations. Geol. Surv. of Can., Rep. Progress for 1871-72, pp. 11-15.

Journal and report of preliminary Explorations in British Columbia. Geol. Surv. Can., Report of progress, 1871-72, pp. 16-72. Montreal. 1872.

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Summary report of Geological investigations by A. R. C. Selwyn, addressed to the Hon. Jos. Howe, M.P., Secretary of State for the provinces. Geol. Surv. Can., Report of Progress, 1872-73, pp. 1-7, Montreal, 1873.

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Notes of a Geological reconnaisance from Lake Superior by the English and Winnipeg rivers, to Fort Garry. Geological Survey of Canada, Report of progress, 1872-73, pp. 8-18, Montreal, 1873.

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1850. No. LXXVI. North. (Bardley). Scale of one inch to a statute mile. London, 1850.

1850. No. LXXVI. South. (Bardsley). Scale of one inch to a statute mile. 1850.

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1852. No. LXXVIII. South West. (Bangor). Scale of one inch to a statute mile. London. 1852. Prepared in conjunction with A. C. Ramsay and W. W. Smyth.

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1854. Horizontal Sections, Sheet. No. 37. Scale six inches to the mile. Geological Survey of Great Britain. Prepared jointly with A. C. Ramsay and W. T. Aveline, London, 1854.

1854. Horizontal Section, Sheet 31. Geological Survey of Great Britain. Six inches to the mile. London, 1854. Prepared jointly with A. C. Ramsay, J. B. Jukes and W. T. Aveline.

1855. No. LV. South East. (Leominster). Scale one inch to the mile. London. 1855. Prepared jointly by J. Billups, W. T. Aveline and H. B. Howell.

1855. No. LXXIII. South West. (Market Drayton). Scale of one inch to a statute mile. Geological Survey of England and Wales. London, 1855. Prepared jointly with Edward Hull.

1855. No. LXXIII. North West. (Market Drayton). Scale of one inch to a statute mile. Prepared jointly with Edward Hull. London, 1855.

1855. No. LXIII. South East. (Market Drayton). Scale of one inch to a statute mile. Prepared with Edward Hull. London, 1855.

1855. No. LX. North West. (Montgomery). Geological Survey of Great Britain. Prepared jointly with J. B. Jukes, W. T Aveline, and Sir A. C. Ramsay. London, 1855.

1857. No. LXXIII. North East. (Market Drayton). Geological Survey of England and Wales Scale of one inch to a statute mile. Prepared jointly by W. W. Smyth and Edward Hull. London, 1857.

ON RHOMBOPORA LEPIDODENDROIDES *MEEK.*

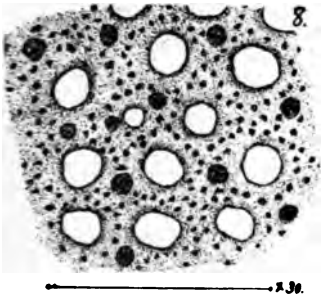
By G. E. Condra, Ph. D., Lincoln, Neb.

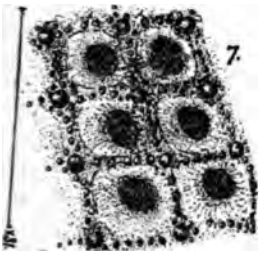
PLATE II. FIGS. 1-10.

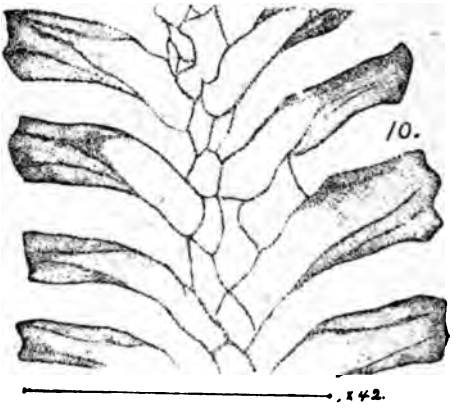
1866. Stenopora columnaris. Geinitz (not of Schlotheim, 1813, (in part) Carb. und Dyas in Nebraska, p. 66.
1872. Rhombopora lepidodendroides Meek, Pal. Eastern Nebr., p. 141, Pl. VII, 2a-f.
1877. Rhombopora lepidodendroides (?). White, Wheeler's U. S. G. S., IV, Pal., p. 99, Pl. VI, 5a-d.
1884. Rhombopora lepidodendroides. Ulrich, Jour. Cincinnati Soc. Nat. Hist., VII, p. 27, Pl. I, 1-1b.
1887. Rhombopora lepidodendroides. Foerste, Bull. Sci. Lab., Denison Univ., II, p. 73, Pl. VII, 3a, b.
1888. Rhombopora lepidodendroides. Keyes, Proc. Acad. Nat. Sci., Philadelphia, p. 225.
1894. Rhombopora lepidodendroides. Keyes, Missouri Geol. Surv., V, p. 35, Pl. XXXIII, 4a, b.
1896. Rhombopora lepidodendroides. Smith, Proc. Amer. Phil. Soc., XXXV, p. 237.
1899. Rhombopora lepidodendroides (?) Meek. Knight, Jour. Geol., VII, p. 366.
1900. Rhombopora lepidodendroides Meek. Nickles & Bassler, Bull. 173, U. S. G. S., p. 395.
1901. Rhombopora lepidodendroides. Rogers, Kans. Univ. Quar., IX, No. 4, pp. 240, 241, 245.

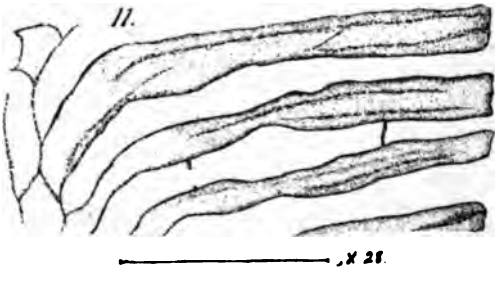
Among a very large number of Coal Measure fossils found in Nebraska, some of which have been of service in determining stratigraphy, the following seem to be the most common and widely distributed: Fusulina secalica, Seminula argentea, Chonetes granulifer, Spirifer cameratus, and Rhombopora lepidodendroides. The last named species has a wide range both vertical and horizontal; it is more or less plentifully found in nearly all Coal Measure exposures of the state, and in the Permian at Blue Springs and Wymore.

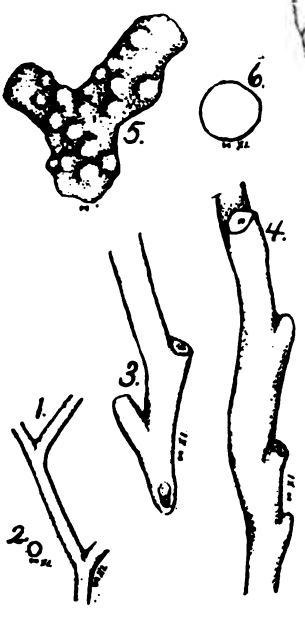
The first specimens were collected from outcrops along the Missouri river by professor Marcou. They were identified by professor Geinitz of Dresden, in 1866 as Stenopora columnaris (Schlotheim 1813, in part). According to Meek, who named the species in 1872, the specimens observed by Geinitz were R. lepidodendroides Meek encrusted by Fistulipora nodulifera Meek. The writer has found several specimens which were quite concealed by Fistulipora nodulifera Meek. It is very

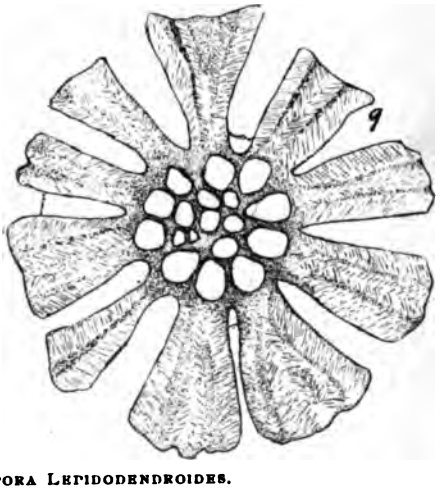












RHOMBOPORA LEPIDODENDROIDES.

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evident, therefore, that professor Geinitz may have erroneously identified two new species, one covering the other, as a single described species.

The object of this brief paper is to announce the positive occurrence of the species in the Permian of Nebraska, and to briefly delineate its different forms of growth, only one of which has been described. Meek's diagnosis is based on the young growth, and, as a result, the species is often imperfectly known by that form alone. The writer has collected and placed in the museum of the University of Nebraska not less than fifty pounds, representing several thousands, of nice clean specimens. They fall under the following growths: 1, young form; 2, old non-montiferous form; 3, old montiferous form, To these may be added the encrusting form which is rarely found. From superficial characters, the casual observer would try separate the specimens into as many species as there are forms of growth.

Description.—Zoaria ramose, rarely encrusting, cylindrical or slightly compressed, straight to irregular in extent between bifurcations, in young and old forms; surface smooth or montiferous; bifurcations at irregular intervals, equal or unequal in size, angle variable, usually 60 to 80 degrees. Young forms (figs. 1, 2, 9, 10.) slender, cylindrical, small, average diameter less than 2 mm., surface papillose, due to projecting acanthopores. Old forms (figs. 3-6, 8, 11.) larger, more irregular, with or without monticules, size variable, diameter 3 to 8 mm., average 4 or 5mm.; monticules of montiferous form differ in size and arrangement as shown by fig. 5.

Zooecia curve gradually from central to cortical portions of zoarium, through which, in old growths, they continue in nearly straight lines to the apertures; walls in central or immature region thin, in cortical or mature portion thick with acanthopores as a prominent feature; acanthopores or tubuli, as they are sometimes called, between zooecial walls, of two sizes, large and small, projecting from the surface when well preserved. Zooecial cavities or cells polygonal in the immature region, circular in section and usually smaller in the mature portion. Tabulae wanting in most cells, but frequently found in old forms. Apertures subcircular in form, arranged (in young growth) in vertical and diagonally intersecting series

which open into rhombic or subelliptical vestibules; Vestibules in very young specimens subelliptical. The intersecting series and vestibules are not plainly shown in old forms.

These brief notes may show that the so-called rhombic vestibule has been overestimated as a character. Probably the encrusting form has been described as a species under Stenopora. The systematic position of the species is held in dispute. Meek placed it under the polypi.

Position and locality.—Coal Measures: "A rather common species at various localities in Nebraska, Kansas, Missouri, Iowa, Illinois, and Ohio." Found at Bennett, Roca, Ashland, South Bend, Louisville, Richfield, Cedar Creek, Plattsmouth, Wyoming, Nebraska City, Tecumseh, Table Rock, Humbolt, Dawson, Salem, Falls City, Weeping Water, Nehawka and other localities in Nebraska. The young form occurs in large numbers at Table Rock, while the old forms are even more plentifully found just above a thick bed of flinty limestone outcropping along the Platte river from Louisville to South Bend. Permian: Some years ago professor Knight collected specimens at Blue Springs and Wymore and referred them with question to this species. Since that time the writer has identified the species in the Florence flint at those places. Professor Prosser has collected and identified specimens from the Permian of Kansas.

EXPLANATION OF FIGURES.

1. Young form outlined natural size.
2. Young form, transverse section, outlined natural size.
3. Old non-montiferous form, outlined natural size.
4. Old non-montiferous form, outlined natural size.
5. Old montiferous form, outlined natural size.
6. Old montiferous form, transverse section, outlined natural size.
7. Young form, surface enlarged, showing vestibules with large acanthopores at the vestibule angles.
8. Old non-montiferous form, tangential section from mature region.
9. Young form, transverse section of zoarium.
10. Young form, vertical section showing transition from immature to mature region as well as form and size of cells.
11. Old non-montiferous form, vertical section showing walls, tabulae, and cells.

NOTE.—Figures 9, 10 and 11 were drawn by Miss E. P. Hensel.

VALLEY LOESS AND THE FOSSIL MAN OF LANSING, KANSAS.*

By WARREN UPHAM, St. Paul, Minn.

The deposition of the loess in the Missouri and Mississippi valleys, forming a most important part of the modified drift supplied from the waning continental ice-sheet, was very directly dependent on a widely extended depression of our vast glaciated area, which, from a later part of its records in the basin of Lake Champlain and the St. Lawrence valley, has been named the Champlain depression, characterizing the closing stages or Champlain epoch of the Ice age. Looking to the causes of the snow and ice accumulation, which prevailed during a relatively long time, attended, however, with great fluctuations of the ice borders, and to the opposite causes of the final departure of the ice-sheet, which occupied comparatively only a short time, we find the Glacial period divisible into two epochs. The first was a time of high elevation of the lands which became glaciated, as known by river valleys on the continental borders now very deeply submerged beneath the sea. Snowfall, instead of rain, predominated throughout the year, giving a general though wavering growth of the continental icefields, with prolonged work of drift erosion and transportation. This was the Glacial epoch, as we may term it, comprising the far greater part of the Glacial period. But it is less fully known, as to the details of its history, than the ensuing Champlain epoch of depression of this glaciated region, when the ice-sheet finally melted away, albeit with many vicissitudes of halting and even occasional readvance interrupting the glacial retreat.

In this epoch, begun by the Champlain subsidence of the land beneath the immense burden of the ice-sheet, the earliest deposits were the loess of the Missouri and Mississippi region and the nearly analogous white silts on the area drained by the Ohio river. With abundant melting of the icefields which supplied these very extensive modified drift beds, the weight pressing down this part of the earth crust was much diminished, allowing it to rise probably [illegible] feet in this great in-

* Presented at the meeting of the A. A. A. S. in Washington, Jan. 2, 1903.

terior region, adjoining the northern ice-sheet, so that when the somewhat later knolly and hilly marginal moraines were amassed along its boundaries at pauses of its recession, a coarser modified drift formation of sand and gravel was spread along the river valleys by the stronger and faster flowing streams that then received the drainage of the ice melting. The valleys had already been reëxcavated from their filling of loess. New floodplains of gravel, sand, and silt, brought by the waters from the ice melting and rains during the Wisconsin or moraine-forming stage, attained great thickness near the ice borders, but thinned more rapidly southward, so that their continuations in the great valleys are now covered, or have been mostly worked over and redeposited, in the Postglacial alluvium.

As fast as the ice-sheet withdrew and left the land bare, it was reëlevated farther north to nearly the same extent of a few hundred feet as before in the upper Mississippi region. A wave of permanent uplift thus advanced toward the central area that was last occupied by the icefields. Not many thousand years, probably, after the loess areas were uplifted, the basin of the vast Lake Agassiz, now represented by Lake Winnipeg, was reëlevated, rising mostly 300 to 500 feet at the rate of about a half of a foot yearly, by a gradual movement advancing from south to north; at nearly the same time, the coast of Maine and the Champlain and St. Lawrence valleys were uplifted to a similar amount: and in the north central area of our continent, including Hudson bay, the uplift still appears to be in progress, averaging for some districts perhaps as high a rate as three to five feet or more in a century. The loess region may have been wholly raised to its present hight far more rapidly, like the Lake Agassiz basin, within a thousand years, permitting the erosion of the loess to take place very soon after its deposition. No longer interval than a few thousand years may therefore have separated the Iowan stage of loess deposition, with its very slow river currents, from the Wisconsin stage of moraine accumulation and attendant trains of gravel and sand washed down the valleys by rapid streams.

The admirable investigation of the physical and chemical characters of our loess deposits by Chamberlin and Salisbury in the paper of their joint authorship, "The Driftless Area of the Upper Mississippi Valley," published in the Sixth Annual

Report of the United States Geological Survey, 1885, leaves no ground for doubt that the loess of the Mississippi and Missouri valleys was derived mainly from the North American ice-sheet, being a deposit of the flooded rivers during a stage of very abundant ice-melting, with considerable redistribution over the interfluvial upland areas by winds. Several years later, an equally important work by McGee, "The Pleistocene History of Northeastern Iowa," appeared in the Eleventh Annual Report of the same survey, presenting most satisfactory and conclusive evidence that the chief stage of plentiful and rapid deposition of the loess was when the ice-sheet still covered a large part of Iowa and stretched thence very far northward, but after it had relinquishd the outer area of its drift which extends south to central Missouri and northeastern Kansas.

Paha, or eskers of loess, described by McGee, and broad swells and embanked ridges of loess, also described by him and by Calvin, amassed along the border of the ice-sheet at its Iowan stage, rising 20 to 50 feet or more above the adjoining almost perfectly level expanse of till on which the ice lay at the time of these loess accumulations, give me a complete assurance that the loess there was supplied principally from englacial drift which at last became superglacial by ablation or surface melting. As with the more common types of eskers and kames, composed of coarse and fine gravel and sand, I am obliged to refer these loess formations to streams flowing down from the dissolving ice surface, not upward from subglacial tunnels. They go with the numerous arguments of Profs. N. H. Winchell and W. O. Crosby, and of the present writer, to prove that the departing North American ice-sheet, when its thickness near the margin was greatly reduced, became covered there by the drift which had previously been enveloped within the slowly flowing ice, nearly as the Malaspina ice-sheet or piedmont glacier in Alaska, between Mt. St. Elias and the ocean, is covered by its formerly englacial drift, on which are now growing forest trees of large size and luxuriant thickets. Similarly the Greenland ice-sheet, if it were melting away instead of increasing or remaining nearly unchanged, would become covered at its border by the drift of its basal part, then becoming superglacial.

On the melting and drift-bearing margin of the ice in the Missouri, Mississippi, and Ohio basins, where a great proportion of the drift is very fine-grained, with usually an appreciable calcareous element, from erosion of limestones or of the frequently calcareous shales of the great Cretaceous areas west of the Mississippi, the superglacial drift, washed by the streams of the ice melting, and of the accompanying copious rains, yielded to the rills, brooks, and rivers discharged from the ice surface, a very abundant freight of fine muddy silt, usually somewhat calcareous. Being laid down in the ice-walled channels of the streams near their debouchure to the open ground, or along the edge of the icefields, this modified drift is preserved to our time in the very instructive loess paha, and in the high loess embankments and slopes that fringe the outer boundary of the Iowan till expanse.

What conditions produced and controlled the deposition of the valley loess? First, this region was differentially depressed, with all the North American area of glaciation, until it stood lower than now, the maximum reëlevation in the Mississippi basin being, as I think, about 500 feet, or, according to the estimate of Chamberlin and Salisbury, probably as much as 800 feet. (The physical characters of the earth crust, and of the plastic or molten interior, which could admit such differential movements, I discussed eight years ago in Monograph XXV of the United States Geological Survey, entitled "The Glacial Lake Agassiz.") Second, with restoration of a temperate climate on the border of the ice-sheet, brought by the subsidence from the formerly high elevation, extensive surface melting of the ice exposed its englacial drift, much of which was washed away and borne into the valleys beyond the ice boundary.

The very fine modified drift in the Mississippi region, called loess, could be carried by the gently flowing streams far along the great valleys, in which it formed thick floodplain deposits, the swollen rivers being uplifted on them to hights of 150 to 250 feet above their present beds. Today the Missouri is sometimes called "the Big Muddy," a name which it well deserves, for at all seasons a white plate lowered into its muddy current becomes invisible within a depth of two or three feet. But during the final melting of the ice-sheet this river

and all the others of this basin were much bigger and much muddier. Though flowing with slackened currents on account of their decreased slope, they carried the fine particles of the loess hundreds of miles down the Missouri and Mississippi valleys, building up wide and thick floodplains as far southward as to Crowley's Ridge in Arkansas, and even onward past Vicksburg and Natchez, thinning out on the shores of the Gulf.

During the summers of each year the floods pouring along the valleys from the ice melting and rains added a little to the surface of the whole floodplain; but in the autumn, winter, and spring, the diminished rivers flowed in comparatively narrow channels, probably permitting the main part of the floodplain to become more or less covered by grass and other vegetation and to be inhabited by air-breathing mollusks. Hence, even in the valleys, the fossil shells of the loess are mostly of terrestrial species. If a quantitative estimate of the average rate of deposition of the loess in the valleys be attempted, I think two or three inches of added thickness in the three or four summer months of the river floods in each year to be perhaps a reasonable supposition, which would require a thousand years, approximately, for the accumulation of the depths of 150 to 250 feet.

From the very extensive tracts of the floodplains, several or many miles broad and reaching along the valleys hundreds of miles, the winds in the cooler part of the year, when these great expanses were bare, blew away much of the fine loess dust and spread it far and wide over the interfluvial higher lands. Received there on a grassy surface, like that of our present prairies, the loess settled from the gales and mantled somewhat uniformly all the land, regardless of its contour or altitude. In these great areas of eolian loess only terrestrial shells are found. Here again we may essay an estimate of the rate of deposition, assuming that the wind action might bring on the average a sixth or a quarter, or even a third, of an inch in thickness yearly, so that within the same thousand years of the valley loess formation the observed interfluvial loess sheet, mostly 10 to 25 feet thick, would be distributed in its surprising uniformity over the high and low lands alike.

Nor were the winds limited to the river floodplains for the derivation of their loess dust. On the drift-enveloped border

of the ice-sheet, which probably differed from that of the Malaspina glacier by having commonly neither trees, grass, nor any vegetation, the gales in dry weather could gather much of this very fine silt, sweeping it off high in the air to be deposited far away with the other interfluvial loess. It should also be added that this silt mantle doubtless includes some contribution, most considerable westward, of dust from the great western plains, this part being not of glacial origin.

According to the well known investigation and report of Humphreys and Abbot, the silt deposited annually by the Mississippi beyond its mouths and on its delta and swamp lands would cover a square mile to the depth of 315 feet. In a thousand years, therefore, at its present rate, the river deposit at and near its mouths would be equal to the measure of a thousand miles in length, two miles in width, and nearly 160 feet in depth. During the rapid glacial melting of the Iowan stage, however, we may reasonably suppose that the mean annual volume of the Missouri and Mississippi was twice or three times as great as now, its floods being prolonged throughout the summer; and the amount of silt gathered from the melting ice-sheet may have averaged fivefold, I believe, or perhaps for some centuries even tenfold, more than the present supply. It seems therefore, by comparison with the work of these great rivers now, that they were competent, when the Champlain subsidence favored rapid melting of the ice, with an abundant supply of silt and very gentle slope of the stream courses beyond the ice border, to deposit the valley loess in the manner and time here indicated. Afterward, too, when the region was somewhat reëlevated as at present, it is evident that the reëxcavation of the valleys would require only a few thousand years to deepen them, as before the moraine-forming Wisconsin stage, to levels below the bottomlands of today.

My principal motive for this study of the loess comes from the discovery, in February of last year, by the Messrs. Concannon in a tunnel cellar on their farm near Lansing, Kansas, of a human skeleton beneath the lower part of the valley loess of the Missouri river, as I regard the geologic section there.*

* Am. Geologist, vol. xxx, pp. 135-150, with two plates, Sept., 1902. The same number also contains, in pages 189-194, an editorial article on this subject, by Prof. N. H. Winchell, including notes on the Lansing skeleton by Prof. S. W. Williston.

This locality was visited by Prof. N. H. Winchell and myself, with others, August 9th. Six weeks later, September 20th, it was visited by Profs. W. H. Holmes, T. C. Chamberlin, R. D. Salisbury, and Samuel Calvin, with others; and a long article by Chamberlin, with short statements from Calvin and Salisbury, has been since published.* Extensive excavations were made there within the next month by Mr. Gerard Fowke, under the direction of Prof. Holmes, to obtain additional observations of the characters of the deposits overlying the skeleton. The result of this investigation is regarded by Chamberlin, Calvin, and Salisbury, as adverse to the conclusions before announced by Winchell and the present writer, which referred the fossil man of Lansing to the Iowan stage of the Glacial period. Instead, they consider him to be of much less antiquity, the overlying 20 feet of silt being thought to be Postglacial alluvium from the drainage area of a little tributary ravine which there joins the great Missouri valley.

Against this view I see two decisive objections, which seem to me sufficient to necessitate the reference of the Lansing man to the loess-forming Iowan stage of glaciation. First, the overlying silt, regarded by Winchell and myself as loess, is predominantly calcareous in nearly the same degree as average loess, though it has some scanty portions that have very little calcareous matter or none; whereas if it were a Postglacial deposit, whether by the Missouri river or the adjoining ravine, or by both together, its material, derived from the weathered and leached superficial part of the loess, from the old Kansan drift thinly spread in that region, and from the weathered Carboniferous strata, would be mostly destitute of its calcareous ingredient. But the proximity of the ravine, of the Kansan drift, and of the Carboniferous limestone and shale beds, gives an ample explanation of the scanty intermingling of materials of local derivation with the otherwise typical loess. While the old floodpain of the Iowan time was being deposited at the horizon of the Lansing skeleton and for the next twenty feet upward, exceptionally heavy local rains, and the snow melting in spring, would sometimes carry down an alluvial deposit of silt from the ravine, or pebbles and larger

* *Journal of Geology*, vol. x, pp. 745-779, with 13 illustrations in the text Oct.-Nov., 1902 (issued about Dec. 5).

rock fragments, such as are inclosed in this section and in most other sections of loess adjoining the rock bluffs of the valley, especially where it receives a small tributary. In this connection we may notice that the Concannon tunnel in its outer half, dug during the winter of 1900-1901, had perfectly maintained its vertically cut sides and slightly arched top a year and a half before our visit, behaving in the manner so characteristic of the loess, which would not be possible in any Postglacial deposit of alluvium.

The second objection to Chamberlin's view relates to his assumption that the Missouri river during some part of the Postglacial period had a floodplain at Lansing about 25 feet above that of the present time. Changes then taking place as to the course of the river's channel are supposed to have permitted the stream in the ravine to deposit the silt above the skeleton. On the contrary, if I rightly read the geologic history of the Missouri and Mississippi rivers, the floodplain at Lansing and southward was lower during the Wisconsin stage of glaciation than now, and has in general been somewhat built up, instead of being cut down, during all Postglacial time. With the uplift of this region which preceded the formation of the Wisconsin and Minnesota moraines, the valleys acquired their present slopes, and the valley loess was rapidly eroded. Its deposit along the Missouri, once having the hight of probably 150 feet above the Lansing skeleton, was removed, giving the valley its present width and even a greater depth than now, before the moraine-forming stage of the waning Ice age. During this process of reëxcavation, the remnant of loess at and above the Concannon tunnel was spared; and here and there, as close north of Council Bluffs, a terrace would be left midway between the crest of the valley loess bluffs and the present bottomland. Sufficient time intervened between the Iowan and Wisconsin stages to allow the great valleys to be sculptured in the easily eroded loess to nearly their present form with a somewhat greater depth. Through this interval the ice accumulation and melting were almost evenly balanced; but there next ensued a time of general and prolonged recession of the ice border, interrupted by many halts shown by parallel and partly interlocking moraine belts. From the abundant melting of this Wisconsin stage, floods again poured

along the valleys and deposited much modified drift. They descended with the same valley slopes as now, and their strong currents bore the finest silt far southward, to the lower Mississippi and the Gulf, while the gravel and sand were deposited along the upper part of the valleys. In the close vicinity of the moraines the outwashed coarse modified drift filled the valleys 100 to 200 feet, or more, above the present rivers; but the fine clayey silt borne farther down the valleys was deposited in much less volume than the earlier loess, being mostly swept on by the river floods to the Mississippi delta. Along the Big Sioux valley, on the northwest boundary of Iowa, a floodplain of modified drift associated with the moraines has an average width, as described by F. A. Wilder, of one and a half miles, and is about ten feet above the present relatively insignificant bottomland, which averages only about a fifth of a mile in width.* Below the junction of the Big Sioux with the Missouri, this floodplain of Wisconsin time continues with a width of 6 to 12 miles on the east side of the Missouri through the distance of 90 miles to Council Bluffs and Omaha, having only the same slight altitude above the river. Southward from the mouth of the Platte river, as I think, the old Wisconsin floodplain was lower than the bottomland today, which has evidently gained in depth, rather than lost, ever since the Ice age. Conditions requisite for silt deposition 30 to 50 feet above the Missouri at Lansing appear thus not to have existed since the Iowan loess was spread deeply along this valley.

It seems needful to add only a few words more. The antiquity of the Lansing man I think to be measured by about 12,000 years, or, at the longest 15,000 years; and this is probably the earliest evidence of man known in relation with deposits referable to glaciation in America. The stone arrowhead noted by Williston† as found with the bones of an extinct species of bison in western Kansas is undoubtedly about equally old. But the stone implements and human bones found by Abbott, Putnam, Volk, and others, in glacial gravels at Trenton, N. J., belong to a later stage in the departure of the continental ice-sheet. Probably almost contemporaneous with these are the evidences of early man made known in modified drift deposits

* *Iowa Geol. Survey*, vol. x. 1900, p. 142.

† *The University Geological Survey of Kansas*, vol. ii, 1897, pp. 297-308. AM. GEOLOGIST, vol. xxx, pp. 313-315, with section, Nov., 1902.

of Ohio by Wright, Mills, Claypole, and others, and in the upper Mississippi floodplain of the end of the Glacial period at Little Falls, Minn., by Winchell and Brower; which, in their turn, antedate the prehistoric hearth in New York under a beach of the glacial Lake Iroquois, reported by Gilbert, and the artificial flakes of stone noted by Tyrrell in a beach on the northwestern shore of lake Agassiz. These all belong, however, to the closing stages of the Ice age, probably ranging from 9,000 to 7,000 years ago. The men of Lansing, and of these later modified drift and lacustrine deposits, were very near our own times in comparison with the antiquity well known for man in Europe. In the Old World man has existed at least 100,000 years, and not improbably even twice as long. In America he may have had 50,000 or 100,000 years for the origin of the physical characters of the American race. Therefore the resemblance of the Lansing skeleton to the average type of our American aborigines, called Indians, appears in no degree surprising to one who believes that the creation of plants and animals has proceeded by the gradual methods of generic and specific development which are collectively termed evolution.

NOETLING ON THE MORPHOLOGY OF THE PELECYPODS.*

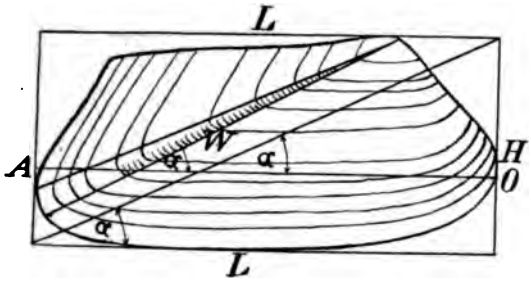
By Rudolf Ruedemann, Albany, N. Y.

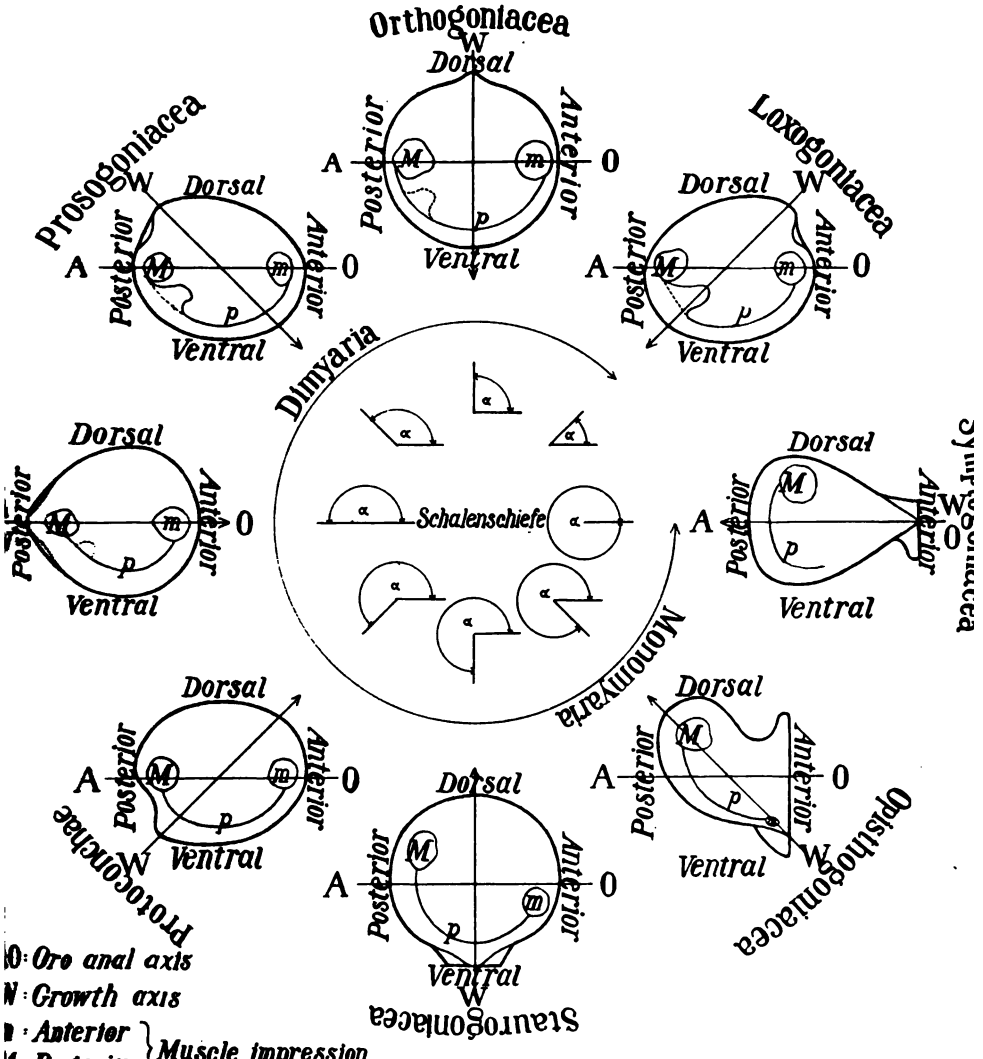
PLATE III.

The most recent of Mr. Noetling's papers on the pelecypods introduces an element so novel and promising of usefulness into the morphology of the pelecypods, that we wish to aid in making it known to the American students of paleontology.

The author admits that he owes the incentive to his investigation to Jackson's suggestive work on the "Phylogeny of the Pelecypoda," in which Jackson establishes the peculiar fact of the torsion of the hinge line in reference to the body of certain pelecypods, but, as Noetling claims, fails to recognize the importance of the discovery, and also considers the axis

* Fritz Noetling: Beitrage zur Morphologie der Pelecypoden. *Neues Jahrbuch für Min. Geol. & Pal.* XV Beilage Bd. 1902.


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Orthogoniacea
Prosogoniacea
Loxogoniacea
Dimyaria
Monomyaria
Schalenschiefe
Cyrtogoniacea
Opisthogoniacea
Protoconchae
Strophogoniacea
Dorsal
Ventral
Anterior
Posterior
W
A
0
M
m
p
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O: Ore anal axis
W: Growth axis
Anterior
Posterior
Muscle impression
Pallial sinus

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of the hinge line as constant. Noetling holds that it would seem a priori possible that the valves or the hinge line should have, in different genera a different position in regard to the principal axes of the animal. He has eliminated the misconception arising from the assumption of the stable position of the hinge line by considering the oro-anal axis of the animal as a constant line. But even this new conception would not furnish the clew to the law of torsion as long as the hinge line is considered (as by Jackson) one radius of the angle of torsion; with Noetling's data a comparison of the valves of Nucula with any sinupalliate pelecypod valve shows, that though in both the axis of the hinge is parallel to the oro-anal axis, a torison of 90° of the valve of Nucula has taken place with reference to that of the sinupalliates.

The suggested law of torsion, however, can not be clearly conceived without a thorough understanding of the relations of hight and length of the shell. The investigation of this relation led to the cognition of the fact that the term "hight," as conventionally derived by placing the shell in a vertical position with the ligament forming the dorsal line, is an indefinite term, in many cases is not homologous and in Pecten and Venus may represent very different axes. Noetling, therefore, defines "hight" and "length" by reference to the oro-anal axis, viz. the length of the shell as the distance between two points nearest the oral and anal extremities and which are hence situated upon the oro-anal axis. With this dimension derived from the position of the animal within the shell the empirical "length" coincides, in the Dimyarians, but not in the Heteromyarians. In a shell of Pecten or Avicula we customarily measure the hight upon the oro-anal axis (See AO in diagram) and the so-called length upon a line connecting the dorsal and ventral margins. The terms have hence been simply inverted and it is evident that confusion herein cannot be avoided.

In the Dimyaria (see Loxogoniacea of diagram) the length goes through both adductor muscles, in the Heteromyaria (Opisthogoniacea of diagram) the length passes between the two and in the Monomyaria (Symptogoniacea of diagram) the muscle has been so far removed from the oro-anal axis that a line, passing through the center of the former is perpendicular to the latter.

Under "hight" one understands conventionally the greatest vertical distance between points of the dorsal and ventral margins. Noetling shows, first, that the length of this line, thus defined, depends largely upon the curvature and the thickness of the shell, which are accidental, indefinite elements.

To eliminate these and because this "hight" is not comparable in Dimyaria and Heteromyaria, the author defines as the "true hight" the distance between the ventral margin and the ventral edge of the hinge-plate, measured upon a line, which is perpendicular to the oro-anal axis and passes through the mouth.

For the mathematical expression of the torsion of the shell it has been found necessary to define a third element of the shell which is considered as of the greatest significance. For example, in the shell of Cypricardia, there is a ridge from umbo to ventro-posterior margin, the umbonal ridge (see diagram 1), which marks the direction of greatest longitudinal growth of the valve. This line is termed the "Crescenz-linie" (growth-axis). Its horizontal projection forms an angle with the oro-anal axis, which is termed the "Schalenschiefe" (obliquity or slant of shell).

It can now be shown that the expression $\frac{H}{L} = \alpha$ (an angle of obliquity) allows the mathematical determination of the Schalenschiefe. The possible values of α between 0° and 360° give an infinite number of stages of torsion which the author chooses to place in 8 groups. In the determination of these groups it is to be remembered that not the shell, but the animal within the shell determines the terms applied to the parts of the shell, and that the oro-anal axis lies in the horizontal line, as it does during the life time of the animal.

The groups are:

1) $\alpha = 0^\circ$ (or 360°), that is, both axes (growth-axis and length or oro-anal axis) coincide. In this case the growth must take place in the direction of the oro-anal axis, and in a posterior direction. These are the *Symptogoniacea* and as classical example for the group is cited Pecten, where growth takes place in an anal direction. The hight $= 0$.

2) $\alpha > 0^\circ$, but $< 90^\circ$, $\tan \alpha > 0$ but < 1. The axis of growth and the oro-anal axis form an acute angle and growth takes place in postero-ventral direction. The hight is

less than the length. For these the term *Loxogoniacea* is proposed. By far the majority of all pelecypods belong to this group, specially the large group of the sinupalliate Dimyaria.

3) $\alpha = 90°$, $\tan \alpha = 1$. Hight and length are nearly equal.

In this case axis of growth and the oro-anal axis form a right angle and the growth takes place perpendicular to the oro-anal axis and in ventral direction. Pectunculus is mentioned as the best example for this group, the *Orthogoniacea.*

4) $\alpha > 90°$, but $< 180°$, $\tan \alpha < 1$, but with different sign than case 2.

The two axes form an obtuse angle and growth takes place in antero-ventral direction; *Prosogoniacea.* These correspond to the Loxogoniacea (see diagram) and a right valve of the Loxogoniacea is similar to a left valve of the Prosogoniacea. Mesodesma donacina and Nucula are mentioned as characteristic representatives and it is stated that in depending solely upon the external characters of the shell, one would consider the longer anterior part as the posterior one, as is done indeed in most descriptions.

5) $\alpha = 180°$; $\tan \alpha = 0$; $H = 0$.

Amphigoniacea. These correspond to the Symptogoniacea, both axes coincide again, but growth takes place in opposite direction, viz. forward. No examples are known to the author, but it is thought that they would have to be looked for among paleozoic forms, which might have the pallial sinus or the posterior muscle near the umbo.

6) $\alpha > 180°$; but $< 270°$; $\tan \alpha > 0$, but < 1; $H < L$.

Here the Schalenschiefe forms an angle in the third quadrant and mathematically we have the case of the Loxogoniacea; and upon the shell the two axes would form an acute angle, but in fact the angle is greater than 2 R (R = right angle, see diagram), and growth takes place in dorso-oral direction, i.e. the ventral organs would lie below the umbo and the dorsal organs near the free shell margin. No examples of these, the *Protoconchae,* are known, and the author concedes that it will be difficult to find any; but adds that among such paleozoic Dimyaria as have an acute "Schalenschiefe" a pallial sinus near the umbo should be sought.

7) $\alpha = 270°$; $\tan \alpha = 1$; $H = R$.

These, the *Staurogoniacea,* correspond mathematically to the Orthogoniacea, but growth takes place in an opposite direction, i.e. dorsally. No example known, but they are to be sought among the paleozoic forms with a rectangular "Schalenschiefe."

8) $\alpha > 270°$, but $< 360°$; $\tan\alpha < 1$, but > 0; $H < L$.

Among these, the *Opisthogonicea,* the Schalenschiefe forms an angle in the fourth quadrant. As $\alpha = 3R + \alpha^1$, the Schalenschiefe forms again apparently an acute angle, but the growth takes place in dorso-anal direction. To this group belong the Heteromyaria and Avicula can be considered as its type.

These are the eight cases, which, according to Noetling, are possible for the size of the Schalenschiefe. In four of these, where $\alpha = 0°$, 1R, 2R, 3R the number of possibilities is absolutely limited but where $\alpha = 0 + \alpha^1$ (acute angle), $1R + \alpha^1$ (obtuse), $2R + \alpha^1$ (acute in third quadrant), $3R + \alpha^1$ (acute in fourth quadrant), the number of possible sizes is indefinite. α appears therefore always as an acute angle and the great difficulty is to determine to which quadrant it belongs. Where the pallial sinus can be observed no difficulty is found to determine whether α lies in the first or second quadrant; the external ligament can also be used for this purpose. The direction of growth of the shell will readily decide whether α lies in the fourth quadrant. If the shell in question covers none of these cases and α is acute it could be logically concluded that it lies in the third quadrant. As with paleozoic fossils both the external ligaments and the pallial sinus often fail of observation, this determination will mostly be very difficult and other criteria are therefore sought for.

The author has the eight cases under discussion, so arranged in a diagram, that they form a closed circle. This diagram is here copied. All figures of valves are placed so that the dorsal side is above and the oro-anal axis (A-O) lies horizontal. W represents the axis of growth, the latter having taken place in the direction of the marker. The central ring of angles represents the corresponding Schalenschiefe, the angle formed by the axis of growth and the oro-anal axis. The torsion of the shells becomes in this diagram directly apparent.

Mr. Noetling then points out the deep hiatus existing be-

tween the Loxogoniacea (sinupalliate Dimyaria) and the Symptogoniacea (Monomyaria), which in this diagram have become adjoining groups; while each of them is in the other direction connected with the next adjoining group; the Symptogoniacea being generally considered as derived from the Opisthogoniacea, and the Loxogoniacea being closely related to the Orthogoniacea. Altogether there seems to exist from the Loxogoniacea in a direction against the movement of the hands of the watch a continuous series of groups, and from the Symptogoniacea with the movement of the hands of the watch. This leads to the conclusion that the two, Loxogoniacea and Symptogoniacea, represent the termini of two series, which are thought to begin with the Protoconchae. In the diagram this supposed phylogenetic connection is indicated by the circle which beginning at the Protoconchae is, in the upper semicircle, marked as the phylum of the Dimyaria, in the lower as that of the Monomyaria.

The problematic group of the Protoconchae which would represent the primitive pelecypods, can be said to possess the following characters: Equivalve, but inequilateral. Two muscular impressions. Pallial line entire, without sinus, situated upon the umbonal side of the shell, i. e. with its convexity directed toward the umbo. Hinge consisting of primary lamellae. Ligament partly external, partly internal. Schalenschiefe between 180° and 270°, and growth in oro-dorsal direction. On the whole the shell would be like that of a common dimyarian, but the animal lay in it turned 180°, so that the ventral organs were situated in the umbonal direction. It is stated that this definition of the Protoconchae tallies in the more important features with that furnished by Dall in Zittel-Eastman's textbook of the Protopelecypoda, and derived from the characters of the prodissoconch. The difficulty of recognizing this important group among the paleozoic pelecypods is conceded, and it is added that only the pallial line and the direction of growth will definitely determine the existence of this group.

The author thinks that these groups could be also used for systematic purposes, specially as several coincide in the whole, with classes of the original system of pelecypods. It would seem, however, to the writer that the groups can not be of equal value, as some represent only a single momentary stage

in the process of torsion, in the Orthogoniacea for instance, that stage where the axis of growth has just become vertical upon the oro-anal axis ($\alpha = 90°$), while the neighboring groups of the Prosogoniacea and Loxogoniacea each comprise an entire extent of torsion of 90°. This becomes also evident from the fact that while the Loxogoniacea are claimed to coincide with most of the sinupalliate Dimyaria, under the Orthogoniacea, it can be only said, that besides Pectunculus also Cardium shows in many cases a Schalenschiefe of 90°. The Orthogoniacea would, hence, appear as only a limitary case of the Loxogoniacea. By applying the mathematical divisions in their full sharpness, the system would, it seems, become too rigid for the use of the biologist and some groups perhaps would be represented only by a few species of several different genera.

In the final chapter of this paper, which it is hoped will inject new life in the difficult study of the paleozoic pelecypods, and will perhaps dissolve the "Palaeoconchae" just as the long esteemed class of the Tetracoralla has been dissolved, paleontologists are cautioned in regard to the use of the terminology, for, assuming the actuality of the torsion, it would be absurd to continue, in Pecten for example, the terms anterior and posterior ears, or to designate the posterior margin as ventral margin, as has been done hitherto. In such groups as the Prosogoniacea the danger is even that right and left valves may be confounded.

NOTE ON THE WEST INDIAN ERUPTIONS OF 1902.

(No true Lateral Craters took part in the Volcanic Eruptions.)

By Geo. Carroll Curtis, Boston

The existence of lower active craters on the slopes of Pelée has been reported in connection with the recent eruptions,* but, after what up to the time of my departure, July 6th, had been the most complete field reconnoissance in St. Vincent and Martinique since the eruption, I am inclined to believe that no true lateral or parasitic lower craters of terrestrial origin have taken part in the eruption of 1902.

* Angelo Heilprin, *McClure's Mag.*, Aug., 1902.
Robert T. Hill, *Nat. Geog. Mag.*, vol. viii, No. 7.

It is quite probable that within the great crater of Pelée there may be several vents besides the summit opening, in fact I observed three very distinct loci from which eruptions appeared to come within the walls of the main crater. From the very nature of the fragmental cone within, it is wholly consistent that volcanic outbursts may fissure it at various places along the flanks, and I am inclined to believe that outbreaks from the lower side of the great interior cone may have frequently been interpreted as eruptions from lower craters. These local manifestations in the main crater, however, no more deserve separation from the main source than would different puffs of smoke which emanate from the periphery of a bonfire.

A phenomenon which I saw to cause much fright among the natives of both St. Vincent and Martinique, was eruption in the beds of rivers. This spectacular, though comparatively harmless expression, I am persuaded to believe is of wholly secondary nature, and of no more subterranean origin than is the cake of ice delivered at the door a source of winter rigor.

The processes of these local eruptions could be seen by close, rational observation on the spot. At a distance they were misinterpreted by all except those who had learned their meaning from studies at close range. There are several immediate causes of these river bed eruptions and those methods by which I have observed them to be brought about.

While returning in a canoe on the afternoon of May 3rd from a trip along the northern shore of St. Vincent, there came on a heavy rain. In a few minutes the water was fairly washing down the land over the cliffs into the sea. Rills became small torrents and hanging drainage creases sent small niagaras black with ash mud down the steep cliffs. Then just opposite a great cloud sprang from the mouth of the Wallibou river, and with a startling roar the heavy clouds rose higher and higher in great convoluting, twisting masses, huge fingers of black earth shot up through the stream in spasms and melted back into the bulging rolls. The eruption column rose to a hight of over a mile, curtaining in our horizon, darkening the sky and raining upon us a snow-like coating of wet ash dust. For over an hour we forced our unwilling boatmen to

hold us in this shower of ash. Next morning a new delta 14 × 40 feet had grown at the mouth of the Wallibou. This eruption was largely due to the swollen stream reaching a hot ash bed.

On June 24th I witnessed the mud flow from Pelée and all the evidence I obtained from revisiting the field to the crater's mouth indicates that this was due to the water sent to the ash beds in the Sèche and Blanche direct by an eruption from the 3 miles distant crater. No other explanation can I make hold, and there is much to substantiate the view.

Origin and Action of Ash Deposits.

Hot ejected rock of varying size from the impalpable dust to boulders 21 × 50 feet have been distributed over the greater portion of the slopes of Mt. Pelée and the Soufrière, but while they seldom average above a depth of four or five feet on the upper surface, concentrations of from 20 to 100 feet have taken place within the narrow river beds.

I am inclined to believe that one important method of this canyon concentration has been during great outbursts when large volumes of water have been erupted together with the heated rocks and dust, and that these masses have rushed down the mountain sides in great avalanches, some reaching the sea direct, forming deltas and even islands, others being deposited as a flood plain within the canyon walls, where the heavier boulders, gravitating to the lower portion, the upper part of the mud flow serves as a blanket to retain the heat. On May 5th the Guerin factory on Martinique was buried some 60 feet under such a flow. The ash retained, at the time of our departure from Martinique, July 6th, sufficient heat to cause heavy columns of vapor whenever the canyon became flooded. It is by the access of water, whether by collection in heavy rain, by stream damming process, or by direct eruption from the crater or otherwise that these hot ash beds give vent to the geyser-like eruptions, sending out great clouds of steam and mud, which give the impression of a primary volcanic eruption. This has led to the belief that true terrestrial craters exist on the lower slopes. This secondary phenomenon has been the most instructive of the recent West Indian eruptions. It lay spread out, literally smoking hot, exposed to the observation of

all who would visit, and it is in a careful study of these tangible remains that the contributions may be made to geological science.

Crater of 1812.

On the north east side of the Soufrière crater at St. Vincent lies a small lateral crater of about ¼ the diameter of La Soufrière. Current rumor has it that this lateral crater which is reported to have been formed by the eruption of 1812, had played an active part in the present eruption, and that the narrow wall between the two vents had been broken away.

On June 7th with Dr. E. O. Hovey and a black guide, Samuel Brown of the destroyed Lot 14 Estate. I succeeded in reaching the crater of 1812 and crawled for some distance out upon the narrow divide which separates it from the great crater of "La Soufrière." The wall was still standing, no evidence that could be gathered indicated the small crater had been in eruption during the recent outbreak.

The eruptions in Martinique have occurred within the somma ring of the great summit crater of Mt. Pelée which though divided into several foci of activity can scarcely be regarded as possessing lateral vents.

From this I believe that while manifestations of volcanic energy in the form of outbursts of dust laden steam within the river beds have been frequently observed, no true lateral volcanic eruptions have taken place and no true lateral or parasitic craters have yet been formed in the West Indian eruption of 1902.

MINERALS OBSERVED ON BURIED CHINESE COINS OF THE SEVENTH CENTURY.

By Austin F. Rogers, New York.

Anything that throws light on the formation of minerals is welcome to the mineralogist, geologist and student of ore deposits. Principal among the objects furnishing such light are the so-called artificial minerals, products of the laboratory and furnace.

There is another class of objects forming, as it were, a connecting link between minerals and artificial minerals which

aid us in studying the formation of minerals. I refer to minerals found on timbers and tools in abandoned mines, on metallic utensils buried for years, on slags exposed to the elements and the like. In these there is an element of the artificial. Man has accidentally placed the objects which are acted upon in certain favorable places but has not directed the conditions of the experiments. In this connection we recall Daubrée's classic researches on the minerals found in the Roman baths at the thermal springs of Plombières.

But it is minerals formed upon and at the expense of buried coins that I wish to consider now. The coins heretofore described are Roman coins, found in France, Algeria, Corsica, and England. Four out of the five minerals observed on our Chinese coins have been observed on these Roman coins.

In grading the grounds of the William Nast College (for Chinese) at Kiukiang, China, a pot of buried coins was discovered. The pot contained about five thousand copper coins. They were brought to this country by bishop David H. Moore of the Methodist Episcopal church, and one of them is given as a souvenir receipt to everyone who subscribes a dollar toward the fund for a college dormitory. No facts regarding the occurrence of the coins were obtainable. They are the circular "cash" with a square hole in the center. On some of them the inscription is well preserved and, according to the printed slip accompanying them, the coinage is of the Kang dynasty, Kai Yuan reign, seventh century. The writer had the opportunity of looking over several hundred coins in the possession of bishop Moore, to whom he wishes to express his thanks. As a rule the coins are not much corroded. On many the inscriptions are plain and a few strokes of the file usually reveals the bright metal of the coin which is largely copper. The minerals observed are cuprite, malachite, azurite, copper, and cerussite. Many of the coins have little, if any, of these minerals while others are almost completely covered on both sides. Some have only one or two of the minerals while others have three or four or in one case five. On one coin, one mineral may be dominant, on another it may be a different mineral. Though some of the coins have cuprite on one side and the copper carbonates on the other there is no regularity of such distribution. In the case of three of the copper minerals, there

is a definite order of succession.—The cuprite was formed first, then the malachite, then the azurite. Nearly all the specimens exhibit this paragenesis.

Cuprite.—Cuprite usually occurs in small but distinct crystals. When the crystals with their brilliant reflecting surfaces are thickly scattered over the surface the coin makes a beautiful specimen. The dominant crystal forms are the cube and the octahedron. There are also the dodecahedron, a trapezohedron and a tetrahexahedron. On the best specimen the crystals present the following combination: cube, dodecahedron, octahedron and a trapezohedron. Several crystals were measured and the first three forms identified, but no indices could be assigned to the trapezohedron. On other coins octahedral crystals occur.

Malachite.—A mammillated structure with concentric layers characterizes the malachite. It has been formed after the cuprite and before the azurite.

Azurite.—Azurite does not occur as often or in as large amounts as malachite. It is often crystalline in structure, its drusy surface following the contour of the malachite, the formation of which preceded it.

Copper.—Small, rough crystals of copper were observed on two of the coins associated with cuprite.

Cerussite.—Cerussite was found on nearly all the coins examined. Though usually in subordinate amount, on one coin it was the dominant mineral. It is sometimes colored with cuprite. The lead probably came from some extraneous source as none could be detected in the coin itself.

With the exception of the copper our occurrence is like that noted by Fletcher* on Roman coins from Chester.

Appended is a list of minerals that have been found on coins with the names of observers, localities and references to publication.

Azurite.—Lacroix—Algeria. Bull. soc. fr. Min. 6: 175, 1883.
Fletcher—Chester. Min. Mag., 7: 187, 1887.
Bornite.—Daubrée—Bourboune les Bains. C. R. 80: 461, 1875.
Gouvenain—Bourbon l'Archambault. C. R. 80: 1297, 1875.
Cerussite—Lacroix—Algeria. ibid.
Fletcher—Chester. ibid.

* Loc. cit.

Chalcocite—Daubrée—Bourbonne les Bains, ibid.
Daubrée—Baracci, Corsica. C. R. 92: 57, 1881.
Daubrée—Flines les Roches. C. R. 93: 572, 1881.
Chalcopyrite.—Daubrée—Begnères de Bigorre. Bull Soc. Geol. France 19: 529, 1862.
Daubrée—Bourbonne les Bains. ibid.
Daubrée—Flines les Roches. ibid.
Gouvenain—Bourbon l'Archambault. ibid.
Cuprite.—Fletcher—Chester. ibid.
Breislak—Torre del Greco. Physische u. lithologische Reisen durch Campanien, 1802. p. 204.
Malachite—Lacroix—Algeria. ibid.
Fletcher—Chester. ibid.
Tetrahedrite—Daubrée—Bourbonne les Bains. ibid.

Columbia University in the city of New York, Dec., 1902.

AN ERRATIC BOWLDER FROM THE COAL MEASURES OF TENNESSEE.

By S. W. McCallie, Asst. Geologist of Georgia, Atlanta.

Two years ago last summer while on a visit to the Etna coal mines located near Chattanooga, Tenn., my attention was called to a bowlder which a short time before had been found near the center of a three-foot coal seam. The main attractive feature of the bowlder to the miners, and apparently the cause which led to its preservation from the waste dump, seemed to have been the glittering particles of pyrite to be seen at several points on its surface. The pyrite was supposed by the miners to be gold, and as a consequence the bowlder was spoken of as the "gold rock."

The writer learned that a short time previous to his visit, the bowlder had been shown to one of the United States geologists, who, though then engaged in collecting fossil coal plants at the mines, broke off and carried away a small piece of the stone. With the exception of the removal of this fragment and a few marks made by the pick in dislodging it from the coal seam, the bowlder was entire and not otherwise mutilated.

The bowlder was elongated, somewhat kidney-shaped, and would weigh when entire twenty or thirty pounds. Its surface was quite smooth and had every appearance of having been water worn. In shape and in size it was not at all unlike

stones frequently met with in or near the larger streams of East Tennessee and North Georgia, but on close examination it was found to be entirely different both in structure and mineralogical composition.

The color of the stone is greenish gray, specked with small, irregular dark and light colored spots. In texture it is fine-grained, none of the individual minerals being made out macroscopically. Thin sections show that it consists of quartz and feldspar phenocrysts and biotite, in a quartz-feldspar ground mass. The feldspar and also the biotite are usually much altered, the former giving rise to scales of kaolin, and the latter to chlorite. Whether these alterations antedate the burial of the rock in the Coal Measures, or are of subsequent date, is an open question. However, the smooth surface of the bowlder would seem to indicate that the stone was polished by water when the minerals were in a comparatively fresh state.

A specimen of the rock submitted to Miss Florence Bascom, of Bryn Mawr, for examination was identified by her as an aporhyolyte, though she suggested that the more general term metarhyolyte might also be used. Miss Bascom was unable to decide definitely from a single slide whether the rock cooled as a lava flow, or as a dike, yet no doubt was expressed as to its classification.

The most interesting question which suggests itself in regard to this erratic bowlder is its source. Its water-worn surface would seem to indicate that it had probably been transported some distance by water prior to its deposition in the coal seam, but even this throws little or no light on its original source, as no rocks of like character are to be found in Tennessee or the adjacent portions of Georgia and Alabama. The stratigraphical position of the bowlder fixes the time of its deposition in the latter half of the Carboniferous age, and as a consequence the lava flow or dike from which the bowlder was derived must antedate that period. This would seem to indicate that prior to the latter half of the Carboniferous age at some point not far removed from the Etna coal mines there were dikes or surface flows of rhyolyte which have since been buried beneath subsequent deposits.

GEOLOGICAL AGE OF THE WEST INDIAN VOLCANIC FORMATIONS.

By J. W. Spencer, Toronto.

The Greater Antilles appear to be nearly devoid of volcanoes. The writer has seen only the remains of one in Jamaica (at Low Layton), and none in Cuba. But there are extensive underlying igneous formations in all these islands. However, in the inner zone of the Caribbean or Windward islands there are many cones, and beneath these and the outer islands there is an underlying volcanic basement. In such of the outer islands as St. Martin and better still in Antigua, and in St. Croix one gets some knowledge of the antiquity of the older eruptive formations. In Guadeloupe the geological records are equally well preserved, on one side, while on the other there are the more recent volcanic cones, which can also be seen in St. Kitts, Statia, Dominiqua, Martinique, St. Lucia, St. Vincent, etc.



In St. Martin and Antiqua the old volcanic basement forms mountains still uncovered by modern cones, as also in St.

Croix. The rocks are essentially an andesyte in form of both lavas and tuffs. Their surface topography is moulded by atmospheric agents into low mountains and valleys. Overlying such a basement in St. Croix and St. Thomas, according to Cleve,* there is a conglomerate containing pebbles with Cretaceous fossils. In this region these basement rocks are so dissected that their remains constitute many of the islands of the Virgin group.

But in Antigua and Grande Terre of Guadeloupe the strata overlying the denuded igneous basement is a sub-aqueous re-distributed tuff with some calcareous beds in the upper zone, over which rest conformably the white limestones, a marly deposit containing Oligocene corals and shells.† South of the Guadeloupe archipelago and Monserrat, the outer islands disappear, and the writer is not aware of the occurrence of the early Tertiary limestones remaining so as to leave evidence of the age of the igneous basement, though by its lithological characteristics and the physical features of its ancient surface one can hardly be far astray in concluding that they are of the same age as the similar formations on the islands to the north. In Barbados the Oligocene limestones reappear, but here there are no igneous deposits. It thus seems that the whole Caribbean plateau beneath both the volcanic ridges and the limestone islands is underlaid by an igneous formation dating back to the commencement of the Tertiary period at least, if indeed these rocks are not as old as those of St. Croix, that is as ancient as the Cretaceous period.

In St. Martin, St. Bartholomew and Antigua, the mountain belts are entirely made up of the denuded rocks of this old igneous formation without a covering mantle. So also, part of Statia, St. Kitts, Monserrat, the southern end of Martinique, portions of St. Lucia and the southern end St. Vincent have their surfaces moulded out of the ancient igneous accumulations; but elsewhere in these islands, as also in Guadeloupe proper and Dominique, they are covered with volcanic materials which constitute more or less of the cones and ridges rising to a hight of 3,000 to 4,000 feet. In these mountainous

* On the Geology of the northeastern West Indian islands. *Trans. Roy. Sociedad Acad. Sci.*, vol. ix. 1870-71.

† See "Geological and Physical Development" of the various Windward islands, in six papers by J. W. SPENCER, in *Quart. Jour. Geol. Sci.*, vol. lvii (1901), pp. 409-543, and vol. lviii, (1902), pp. 341-365.

islands, there is not merely a combination of late and ancient eruptive deposits, but there are several formations secondarily derived from the remains of the older basement, and here is room for more study than has been attempted.

The history of one is more or less the history of all these conical islands. For instance, in Dominique there is the old andesitic rock overlaid by volcanic breccia or conglomerate. At other points the age of the tuffs cannot at present be assigned, but some of them have been denuded into relatively large valleys which have been partly refilled with still newer tuffs (like that of the Roseau valley) containing an abundance of water-worn pebbles, often arranged in lines among the more angular material. Such may correspond to the early Tertiary sub-aqueous tufaceous beds of Grand Terre (Guadeloupe). And these beds have been subsequently tilted outwards at considerable angles. As in St. Martin, Antigua and Grand Terre, there is nothing to show that there were any mid-Tertiary eruptions when the whole region was somewhat elevated and the denuding agents were moulding the surface into rounded outlines. From the corresponding topography in the more volcanic islands, where not surmounted by the modern cones, the impression is left that the volcanic activity of the region was quiescent during much of the Miocene-Pliocene period, before the building up of the cones and ridges; which were constructed at a relatively late date; for we find the sea-bed elevated along with these ridges. Thus we find in Statia and in St. Kitts volcanic cones raised by an upward thrust which carried along with it the sea-floor covered by about 30 feet of marl, now forming broken mantles surrounding the cones to elevations of from 400 to 900 feet. Elsewhere, however, we find fragments of a similar formation appearing with the volcanic rocks brought up by a general elevation of the island. These limestone marls contain practically a living fauna, thus showing the elevation to date no farther back than the end of the Pliocene period. Again there are two series of gravel formations, one of which is older than the coralline strata just mentioned as interbedded with the volcanic ejectamenta; but this gravel formation had its surface greatly denuded before the formation of the marl. Again, both the marl and the gravel have been further subjected to erosion so as to often be only

left in broken series. The newer gravel has not been subjected to so much denudation. The youthful lavas have been seen both in Dominigua and St. Kitts, beneath the stratified gravel beds at present not determined as to whether belonging to the older or newer series. The lower gravels in their succession correspond in position to the Lafayette of the continent, and the upper gravels to that of the Columbia. The eruption which raised the cones in St. Kitts and Statia, above referred to, appears to have occurred during the subsidence which gave rise to the upper gravels provisionally regarded as the equivalent of the Columbian series,—a mid-Pleistocene formation—and the marl beds thus raised rest upon an incoherent bed of volcanic ashes, containing living fauna. From all facts before the writer it seems that the volcanic ridges owe their origin to volcanic activity which re-commenced about the close of the Pliocene period, and that the eruptions have continued with more or less interruption down to the present day, for we find that the cones and ridges have not become so deeply dissected by rains and streams as would be expected had their growth not been continued more or less continuously from their re-birth at the close of the Pliocene period to the present year of recorded activity.

EDITORIAL COMMENT.

THE DIAMOND MINES OF SOUTH AFRICA.

Just how much of the popular interest in diamonds is due to their value and beauty for personal adornment and how much to the difficulties in the way of satisfactorily accounting for their origin, it is perhaps impossible to say. The true scientist would, undoubtedly, claim that with him the latter interests were paramount. Still, there exists in our minds a doubt if, were diamonds as cheap and abundant as quartz crystals, the interest, even of these, would be as intense.

Be this as it may, from the earliest period when stones of high refractive index were faceted, the diamond and all relating thereto has possessed a fascination for the general reader beyond that of all other gems. A recent work, "The Diamond Mines of South Africa" by Gardner F. Williams (The Mac-

millan Co., 1902), adds one more to a long list of titles and presents the subject, so far as South Africa, at least, is concerned, in a manner never yet equaled for attractiveness and thoroughness. The work comprises 681 royal octavo pages, with 29 photogravure plates, 11 maps, and nearly 500 figures in the text. There is space here, certainly, for a satisfactory review of the subject, and it has been, apparently, well utilized. Numerous references to other writers and the fact that the writer is general manager of the De Beers Consolidated Mines tend to give the work an air of authority which it might not otherwise possess.

The book begins with an account of the ancient Adamas, the references to the diamond in early scriptural and profane literature, a chapter on the traditional Ophir Land, including a history of the various settlements in South Africa and the final crowding out of the Boers from the Cape Colony by the British and their trekking into the Transvaal. The stories of the experiences of these hardy emigrants and their conflicts with the natives read almost like the early histories of the western emigrants in our own country.

The matter of the early discovery of the diamond is taken up in considerable detail and the account which the writer seems to regard as most authentic is the one which has heretofore often found its way into print. It tells of the finding by a farmer's child of one little white stone, which was carried home and left carelessly lying about upon the floor until discovered by a neighbor, Schalk van Niekerk, to whom it was given by the mother of the child, and who subsequently placed it in the hands of a traveling trader, John O'Reilly. From O'Reilly it passed into the keeping of the acting Civil Commissioner at Colesberg, Mr. Lorenzo Boyes, and then to Dr. Atherstone at Grahamstown, by whom it was finally identified as a diamond. This finding, however, failed to create any great sensation, and it was nearly ten months later that a second one was found, and this at a point some thirty miles distant.

In March, 1869, a superb white diamond weighing 83½ carats was picked up by a Griqua shepherd boy at Zendfontein near the Orange river. This also passed into the hands of Schalk van Niekerk, who paid for it five hundred sheep, ten oxen, and a horse, and subsequently sold it for £11,200 to Lil-

ienfeld Bros. of Hopetown. This stone was finally purchased by the Earl Dudley for £25,000, and was apparently the stone which first made the South African fields famous.

A graphic account is given of the motley throng of fortune hunters who poured into the region after the boom was fairly established and the confusion of titles which arose through conflicting mining claims. Details are also given of the manner in which the mines passed from the control of the Dutch and the native tribes into the hands of the English. The history of the development of the various mining claims and the final consolidation through the work of Cecil Rhodes and the young Hebrew, Barnett Isaacs, or Barney Barnato, as he was called, is given in considerable detail. Abundant illustrations show all the details of mining and various stages of development, and much that is incidental thereto.

What is the least satisfactory chapter in the book, to the scientific man, at least, is that relating to the genesis of the diamond. Here no reference is made to the work of Daubree or De Launay, though the work of Carvill, Lewis, W. Luzi, and Rutley is quoted.

The closing chapter, "An Uplifting Power," has to do with the development of South Africa through the discovery of the diamond mines, and an appendix with the condition of the mines during the South African war. It would require no reference to the title page to assure the reader that both the latter were written by an Englishman and from an Englishman's standpoint, by one who was perhaps too near the scene of action and too closely connected by ties of blood to look at matters from a wholly impartial standpoint. G. P. M.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Om Slarpsbäckens Dalgang, af John Chr.. Moberg (Aftryck ur geol. foren. i Stockholm förhandl., Bd. 24, H. 5, 1902.)

This is a description of the vale of Sularp showing the outcrops of the several beds of shale with various species of graptolites, that are found along its course. The shales are Ordovician throughout. A map of the valley, showing the various features of interest along its course, accompanies the paper. G. F. M.

A Contribution to the Petrography of the John Day Basin. By FRANK C. CALKINS. (Bull. Dept. Geol. of the University of California, Aug., 1902, vol. 3, No. 5.)

The John Day Basin has yielded such important contributions to vertebrate paleontology that its history is of unusual interest. This paper shows the region in a new light, namely that of an important petrographic province.

Since the beginning of Cretaceous time the region has been defined as a basin of accumulation, conditions of sedimentation alternating with volcanic eruptions. It has suffered frequent crustal disturbance, and has been subjected to more or less erosion both in recent time and in various intervals between volcanic outbursts. The material appears to be largely of pyroclastic origin.

Considered as a petrographic province, the John Day basin seems to be characterized by the fact that its rocks are derived from gabbro-peridotyte and granito-dioryte magmas, with an entire absence of rocks of the nepheline group. The analyses show a preponderance of soda molecules over potash and a recurrence of anorthoclase-bearing rhyolytes in Eocene, Miocene and Pliocene times.

The order of succession of types affords a fairly strong confirmation of Iddings's theory that the normal succession is from intermediate to more basic and more acid types. In the Eocene there was a complete cycle of this kind: in the Miocene and Pliocene a second: a recent ash represents the beginning of a third cycle.

The great preponderance of pyroclastic material indicates that these beds were mainly of terrestrial origin, and affords further evidence in favor of the theory of Matthew and disproof of the lacustrine origin of these beds. I. H. O.

Maryland Geological Survey, Volume IV. W. BULLOCK CLARK.

Since the organization of the Maryland Geological Survey in the spring of 1896 four volumes of the general reports have been issued and three volumes of special reports.

The present volume, the fourth in the series of general reports, possesses the same high degree of practical and scientific excellence which has characterized the other publications of the Survey.

A discussion of *Paleozoic Appalachia or the History of Maryland during Paleozoic Time* by Bailey Willis constitutes Part I. of the volume, and comprises the geologic history of eastern North America from the pre-Cambrian time to the present.

The paper opens with a discussion of the geologic processes which make geologic history and proceeds with an account of the development and wasting of Appalachia, the advance and retreat of the Mediterranean sea of North America, the growth of Paleozoic coastal plains, the accumulation, dislocation and folding of Paleozoic sediments, and the formation of post-Paleozoic peneplains.

This exposition possesses the rare value, which the author's perfect familiarity with the great multiplicity of facts presented by the Appal-

achian field, his experimental mastery of the dynamics of rock movement, his ability to draw broad generalizations and his unusual lucidity of statement, are able to give to it. The paper presents an invaluable reading lesson for college students of historical geology.

Part II. contains *The Second Report on the Highways of Maryland* by Harry Fielding Reid and A. N. Johnson. The first report presented the condition of the highways throughout the state and outlined methods of improved road making.

The present report gives an account of the work which has been conducted under the supervision of the Highway Division of the Maryland Geological Survey: It describes some new methods of testing road material which have been devised in the laboratory of the Division, and closes with a report of the Baltimore County Roads Engineer.

The report makes very clear the important fact that the highways of Maryland can be permanently improved by the intelligent use of means now available in the state without additional cost. The work of this division of the Survey is plainly of immediate practical value to the state.

Part III. comprises a *Report on the Clays of Maryland* by Heinrich Ries. The report opens with an elaborate discussion of the origin, properties and uses of clays with special reference to those of Maryland. Dr. Ries also discusses methods of testing clays and shows how qualities injurious to the clay for commercial purposes can be counteracted by the addition of proper ingredients.

The second part of the report deals with the geologic distribution and character of the Maryland clays and their relation to transportation facilities.

Maryland ranks eleventh in the list of clay producing states and seventh as a producer of pottery and yet possesses a very large unutilized supply of plastic material. It is the aim of this part of the report to bring to public knowledge the distribution and character of this unutilized material. A bibliography of accessible publications on clay and a directory of Maryland clay workers are appended.

This exhaustive report on Maryland's clay wealth by an expert in the subject must possess great interest for the practical operator. All the reports are well and fully illustrated by maps, cuts and photographs. F. B.

Les roches volcaniques de la Martinique. A. Lacroix (Comptes Rendus. May. 1902.). Prof. Lacroix here recalls descriptions of the rocks of Martinique published by himself in the *Comptes Rendus* in 1890. They were specimens of the collection of Ch. Sainte-Claire Deville preserved in the College de France at Paris. He showed that the presence of hypersthene in the volcanic rocks of Martinique and of Guadeloupe is an essential and almost constant character.

"The earlier volcanic rocks are divided into three groups: dacytes, andesytes and labradorytes. They form dykes, flows and conglomerates accompanied by beds of ash.

"*Dacytes.* The medium type of these rocks presents the greatest analogy, in outer aspect, with the esterellyte of San Raphael. With the naked eye can be distinguished large crystals of quartz with double terminations, hornblende biotite, hypersthene and plagioclase scattered in a microcrystalline paste of a bluish gray color. The rocks of Grand Piton, of the rocky Piton of Morne near Macouba, afford good examples.

"With the microscope it can be seen that the hornblende and the biotite are in course of resorption, the feldspars are much zoned, generally with the central part most basic, but often also with a succession of zones alternating of two different feldspars. These feldspars are nearly always flattened parallel to g^1, with a combination of Carlsbad, albite and pericline twinning. Their determination is therefore quite easy. The most common types are labradorite with 60 per cent of anorthite, and andesine. Vitreous inclusions with bubbles are abundant, as in all the other volcanic rocks of Martinique. All these phenocrysts have a great tendency to unite together and form small segregations. The hornblende crystals are frequently ophitic with the feldspars.

"The paste of the rock is constituted essentially of very small feldpathic microlites, often themselves zoned, andesine and oligoclase. They are accompanied by quartz, sometimes granular, sometimes poecilitic; frequently there exists numerous microlites and crystallites of hypersthene. A considerable amount of titanic magnetite is seen sometimes in the microlites and sometimes in the phenocrysts.

"*Andesytes with hypersthene.* The petrographic type which appears to be the most widely extended consists of acid andesytes of a light color, often having a porous or scoriaceous paste, rough to the touch, but which, in certain cases, is more compact and acquires a dark color in consequence of the abundance of vitreous matter. These rocks are andesytes with hypersthene in which the rhombic pyroxene is sometimes accompanied by a little augite. The phenocrysts are, besides, formed of plagioclase of the andesine group. They are much zoned, but much less than in the labradorites. All these crystals are disseminated in a glassy material which is more or less abundant, the feldspar microlites of which give extinctions that are sometimes longitudinal and sometimes oblique, only rarely reaching twenty degrees. (Carbet Laillet river, west flank of Mont Pelée, environs of St. Pierre, of Precheur etc.).

"In several localities the glassy matter is replaced in part by globular quartz sponges, the secondary character of which does not appear doubtful. (Upper valley of Pirogues, summit of Morne Jacob, etc.)

"*Hypersthene labradorytes.* These rocks are distinguished, generally by the naked eye, from the andesytes by their doleritic aspect; they are usually of a dark gray color and more or less compact. Under the microscope it can be seen, further, that the hypersthene is often surrounded by the augite with their axes parallel. Finally, sometimes olivine is apparent. The plagioclases are more zoned than in the pre-

ceding rocks. These very regular zones indicate considerable variation in composition which it is easy to individualize by reason of the almost constant presence of Carlsbad and albite twinning. One crystal observed, presented in its periphyry zone, perpendicular to the bisectrix N_g extinctions of 24° (labradorite with 55 per cent of anorthite) and at the centre an extinction of 51°, and the latter ought therefore to be classed with almost pure anorthite.

"The microlites are themselves more basic, and exceed 20°. They are often accompanied by microlites of augite and of hypersthene. The study of a large number of specimens from the vicinity of Macouba, from the rivers Laillet, La Garde, and of blocks obtained in the conglomerates of the same regions, causes me to believe that there exists a continuous series between these andesytes and these labradorytes.

"Certain ones of the labradorytes contain no augite, but are rich in phenocrysts of ophitic hornblende. A homogeneous inclusion shows itself to be constituted of a basic dioryte (labrador-bytownite, hornblende, hypersthene, augite) which ought to be considered as a deep-seated form of the labradorytes.

"*Augitic labradorytes.* In conclusion there is reason to cite several rocks having a basaltic facies which are augitic labradorytes, with or without phenocrysts of basic plagioclase and of olivine. These are without phenocrysts of pyroxene (Fort de France).

"The above summary description shows that the volcanic rocks of Martinique constitute a petrographic series remarkably distinct, comprising rocks with free quartz (dacytes), rocks without quartz which by order of their increasing basicity are andesytes and labradorytes. Their common characteristic is their common essential element, a rhombic pyroxene, accompanied frequently by augite and by hornblende. The whole series is remarkable for the abundance of plagioclase phenocrysts. These are rarely homogeneous, but present the most beautiful examples that could be imagined of regular zones formed of differing composition.

"To which of these petrographic types is it necessary to refer the products ejected to-day by Mont Pelée? We have as yet very little information on this point. Nevertheless the ashes that fell on the night of the 3d and 4th of May, the only ones that as yet we possess, described by Michel Levy at a previous meeting, have a mineralogic composition which approaches the hypersthene andesytes described above. They are very similar to a specimen of the collection of the Museum from the eruption of August 5th, 1851, and obtained in the form of a coating on a tree. Yet another specimen, of coarser ash, of 1851, is rich in fragments of hornblende. (May 26, 1902.)"

In a later contribution to Martinique (June 2, 1902) Prof. Lacroix has instituted a comparison between the ash of Mont Pelée of 1851, and the ash of the present eruption, and states that they differ very little, being very similar also to the ejecta of Mt. Shasta, in California, as determined by Hague and Iddings. They are hypersthene andesytes, notably less acid than those of Santorin (1866) or of Krakatoa, richer in alkalies, and poorer in alumina, magnesia and in lime. N. H. W.

Structural Details in the Green Mountain Region and in Eastern New York. By. T. NELSON DALE. Bulletin of the United States Geological Survey, No. 195.

This is the second paper published by Mr. Dale under this title; the first paper appeared in the Sixteenth Annual Report of the U. S. Geol. Survey. (Pt. I., 1896, pp. 549-570.) Like the first publication the second is not a systematic exposition of the geology of the districts named, but a discussion of geologic details collected in the course of the exploration and mapping of seven U. S. Geological Survey sheets. These are the Castleton, Pawlet, Equinox and Bennington sheets in western Vermont. The Greylock sheet of northwestern Massachussetts and the Berlin and Tracy sheets in northeastern New York.

The formations underlain by Pre-Cambrian gneiss, include the sedimentary series of the Algonkian, Cambrian and Ordovician—schists, quartzytes, slates, marbles, limestone and dolomytes. The intense dynamic action to which they have been subjected has given rise to both open and close folding and in some cases, to faulting and shearing. As an exceptional occurrence, however, a recumbent isocline is described at Dorset, Vt., on the Pawlet sheet, a little southwest of Green Peak. Here also is shown a tendency to pinched folding which is more fully developed to the north on the Castleton sheet, at Pittsford. Some of the folds have suffered elongation so that the beds are thinned along the limbs and thickened at the crest.

Perhaps the most noticeable feature of this locality is an overthrust fault which begins at Pittsford and extends south for about ten miles to the town of Clarendon. The tangential force has been of sufficient intensity to produce a thrust fault whose strike is nearly north and south. The relation of the faulted beds is well shown on Boardman Hill north of Clarendon where Cambrian quartzyte on the east side of the fault is in contact with Upper Ordovician schists of the west side. There are two excellent plates which show how the overturned major folds of the Cambrian quartzyte are plicated by minor folds. In Arlington at Roaring Brook on the Bennington sheet, shearing accompanies folding. The shear is indicated by borings of the *Scolithus* which were originally perpendicular to the bedding but are now deflected many degrees from verticality.

The remainder of the paper is for the most part devoted to the discussion of the lithologic character of some of the formations, as well as to their structural relations. The Vermont marble is not a pure crystalline limestone, but is made up of coarse grained calcite marble interbedded with a fine grained rock which, by chemical analysis, was proved to be a dolomyte. Since both marble and dolomyte have undergone the same pressure, the difference in grain must be due, either to a difference in their behavior under pressure or to a difference in the original sediments. The Ordovician schists of the region are more interesting; the constituents are muscovite, quartz, chlorite, magnetite and albite feldspar with which are associated

graphitic streaks parallel to the bedding. Shearing has also produced in the rock, a slip cleavage at right angles to the bedding. The rock is defined as a feldspar schist developed from a sediment. The presence of albite places the formation among the gneisses. It is not unlike much of the schistose mica-gneiss of the Piedmont plateau.

The paper closes with a discussion of the doubtful conformity of the Cambrian rocks on the Pre-Cambrian gneiss. Good contacts are few but three are cited in the Green mountains where there is an evident unconformity in the strike of the rocks. As yet the discrepancy has not been explained which exists between these localities and others on Hoosac mountain, where the contact is conformable. Further study of this and other regions is necessary to harmonize these observations. A. J.

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CORRESPONDENCE.

APATITE CRYSTALS, ANTWERP, NEW YORK. The following is the analysis of some crystals of apatite that were obtained near Antwerp, Jefferson Co., New York, some time ago. They were olive green prisms and were about two centimetres long, and eight millimetres in diameter. The analysis was made in the chemical laboratory of Cornell college by assistant Frank L. Hann.

CaO	48.20	
P_2O_5	41.00%	
$Ca_3(PO_4)_2$		89.20%
SiO_2		0.60
Al_2O_3		9.00
CaF_2		1.20
		100.00%

Mount Vernon, Iowa, Dec. 24, 1902. NICHOLAS KNIGHT.

FALL EXCURSIONS OF THE GEOLOGICAL DEPARTMENT, COLUMBIA UNIVERSITY. The weekly fall excursions of the Columbia geological department closed, as usual, on the last Saturday in November. These are usually half-day excursions and take place on Saturday forenoon. Local sheets of the U. S. Geological Survey, note books, hammers and compasses are necessary for each participant. Each excursion is guided by at least one officer of the department. New York city, especially Harlem and its environs, is an ideal place for short excursions of exceptional geological interest. The university itself is situated upon the area of the Manhattan schist which is believed by state geologist Merrill to be metamorphosed Hudson River shale. This schist is exceedingly full of pegmatyte dikes in which there is frequently a great abundance of tourmaline. There are also veins or interbedded strata which are now hornblende. These are of problematic origin. In places they are very numerous varying in width from a fraction of an inch to several feet and in length extending at times through an entire outcrop several hundred feet. They frequently end very abruptly. The Manhattan schist is at times so full of garnets as to merit the name of garnet schist. This is well shown just north of the convent of the Sacred Heart on 135th St. near Amsterdam Ave. There are fine examples of pinched folds in the Manhattan schist where folded in the more gneissoid strata. The schist is frequently pinched into complete cylinders. These were noted and described many years ago by Prof. Dana.

The Manhattan schist rests, apparently conformably, upon the Inwood limestone. This is a very coarsely crystalline rock which weathers into a coarse lime-sand. On account of its great solubility it usually occupies the valleys. Prof. Hobbes has lately readvanced an old theory, held by Dana and others, of the fault formation of these valleys. The valley breaking through Morningside Park ridge at 125th

St. and forming the valley between the hights of Columbia University and those upon which the convent of the Sacred Heart is situated is frequently brought forward in support of this view. In this rock at the contact with pegmatyte dikes very good specimens of foetid quartz, phlogopite, white pyroxene and brown tourmaline are obtained. The Inwood limestone, called by Merrill Cambro-Silurian, is exposed at 7th Ave. and 155th St., and at the typical locality Inwood, immediately north of Fort George (Amsterdam Ave. and 119th St.)

Beneath this limestone is the Fordham gneiss which is thought to be of igneous origin and of Archean age. An unquestioned exposure of this rock is not known upon Manhattan island; but north of the island are abundant exposures.

Above the Manhattan schist is the Triassic sandstone which is well shown on the western side of the Hudson. The base of this sandstone a conglomerate, is well exposed in a cut made by the West Shore R. R. at Stony Point. The sandstone is penetrated by the Palisade sheet of diabase. The sandstone both above and below the diabase is baked into a hornfels in which the characteristic metamorphic minerals are usually present. In places this becomes a tourmaline hornfels from the great development of that mineral. The effect of the cool walls upon the intruded igneous mass is very evident as one follows the sheet from its lower to its upper contact on the sandstone. The middle of the sheet is very coarsely crystalline but becomes quite fine grained as the wall is approached. Mr. A. L. T. Quereau has lately given the results of his study on the subject in the School of Mines Quarterly, Vol. XXIII. This diabase sheet with its columnar jointing forms the well known Palisade on the west bank of the Hudson river. The lower contact is well shown at the 130th St. ferry. Here is an excellent place to note the gradual change in the texture of the diabase as the Palisades are ascended. The upper contact is shown at the tunnel of the West Shore R. R. at 34th St. ferry. Besides the intruded sheet there are above it, farther west in New Jersey three surface flows; for the upper surface of each is amygdaloidal. The first or lowest flow is well shown at Feltyville. At the Great Notch on the Greenwood Lake division of the Erie R. R. is an excellent place for the collection of minerals. These occur between two of these surface flows in the interstratified baked shale. Here are found quartz, calcite, analcite, heulandite, stilbite, prehnite, natrolite, datolite, pectolite, chabazite and other minerals. Faults are quite numerous in the Triassic, one of which is exposed at Kingspoint near Hoboken.

Another interesting rock which the classes always visit is serpentine. It is well exposed in Hoboken at Castle Point. The problem of its origin is still debated, but is thought by most to be an altered peridotyte or pyroxenyte, since the presence of pyroxene, amphibole and olivine has been determined. The processes of serpentinization are however nearly complete. This is the home of various magnesian minerals as brucite, nemolite and magnesite. Chromite is also abundant.

Good illustrations of peneplains are seen here on all sides in the uniform hights to which the different rocks have been eroded. The gneiss schists sandstone and dikes rocks varying much in hardness, have been eroded approximately to the same level. Many other points in the physiography of the region are impressed upon the students in their trips. Glacial drift and striations are abundant in and about the city.

On election day an all-day trip is taken to some point within fifty miles of the city. This fall it was up into the Hudson River highlands. The West Shore R. R. was taken to Grassy Point and from there the class walked to Ft. Montgomery. On the way excellent exposures of Champlain clays were noticed and the consequent development of the brick industry. Near Stony Point where lunch was eaten, the Basal Triassic conglomerate and the contact of mica schist on the Cortlandt eruptive series were noticed. North of Stony Point fine exposures of Cambrian limestone were examined carefully for fossils but none were found. Farther north still the class entered the highlands with its Archean gneiss, trap dikes and celebrated scenery.

HENRY W. SHIMER.

PERSONAL AND SCIENTIFIC NEWS.

IN THE WINTER COURSE OF LECTURES of the Chicago Academy of Sciences are the following geological topics: The Yellowstone National Park, Charles Truax; Some methods of Geological field work, U. S. Grant; Flying reptiles, S. W. Williston.

THE UNITED STATES GEOLOGICAL SURVEY has commenced another series of publications, denominated "Professional Papers." The first of this series is that of Dr. A. H. Brooks, recently issued. "Preliminary report on the Ketchikan Mining District of Alaska, with an introductory sketch of the geology of southeastern Alaska."

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting of the society on January 14th the following program was presented: "An instance of replacement of mortar by metallic copper," Arthur C. Spencer; "A genetic classification of ore deposits," Walter H. Weed. The discussion of the last paper was led by Messrs. Emmons, Lindgren, Spurr and Ransome.

THE BATH FURNACE METEORITE fell at Bath Furnace, Kentucky, on the night of November 15. It was found buried about a foot and a half in the ground. Its weight is about five pounds. It was observed from New Orleans northward. It is now in the Ward-Coonley collection, on deposit in the American Museum of Natural History. It is of gray stony

material, and is supposed to be only a part of the original mass that entered the earth's atmosphere.

DR. J. W. SPENCER, accompanied by Mrs. Spencer, left on Jan. 7 for the Windward islands, intending to be absent for over three months, where six years ago he also spent over five months. Dr. Spencer is investigating the submarine Caribbean ridge extending to South America. He has found that an Oligocene white limestone underlies the St. Martin group and Antigua, and he will re-examine these islands with the view of more detail, the volcanic phenomena being a secondary consideration.

THE AMERICAN INSTITUTE OF MINING ENGINEERS will hold its eighty-third meeting (the thirty-third annual meeting) in Albany, New York, beginning February 17, 1903. The headquarters and places of session have not yet been announced. It is expected that at this meeting trips will be taken to the shops of tihe General Electric Company, and there is a promise of several interesting papers on electricity as applied to mining. The Institute has accepted an invitation to hold its August meeting in British Columbia, and in connection with this meeting there will be an excursion to Alaska. The library of the Institute now numbers some ten thousand volumes on mining and geology, and this library is now accessible for the use of members.

NEW MEXICO ACADEMY OF SCIENCES. At the winter meeting of the New Mexico Academy of Sciences, held at Las Vegas in the assembly hall of the Normal University, December 22-23, Hon Frank Springer was elected president, Dr. Charles R. Keyes, vice-president, and Prof. W. G. Tight, secretary-treasurer.

The following geological papers were read: Theory of Meteoric Agglomeration and the Migration of Ore Materials, by Dr. Charles R. Keyes; History of the Rio Grande at Albuquerque, Prof. W. G. Tight; Louis Agassiz, by Mr. Frank Springer; Analyses of New Mexico Waters, by Prof. F. C. Lincoln; Relations of Moisture in Mesa Soils, by Prof. C. L. Magnusson; Gypsum Deposits of New Mexico, by Mr. Harry Herrick; Geological Structure of New Mexican Bolson Plains, by Dr. Charles R. Keyes; Sources of Errors in Our Land Surveys, by Prof. O. R. Smith; Geological Sketch of the Sandia Mountains, by Prof. W. G. Tight.

A committee of three, consisting of Dr. Charles R. Keyes, Hon. Frank Springer and professor W. G. Tight, was appointed to present the matter of a geological survey to the New Mexican legislature this winter.

Resolutions were passed recommending to Congress the desirability of establishing a National Ethnological Park north of Santa Fe, in one of the richest districts of prehistoric ruins

in the world. The object is to preserve this intensely interesting region from further depredations and vandalism.

THE LATE MEETINGS OF THE GEOLOGICAL SOCIETY OF AMERICA, of the American Association for the Advancement of Science, and of over twenty other scientific societies, at Washington, were an event of no ordinary importance for American science. No such gathering of scientific men resident in America ever before took place. The only meetings that could be compared with it were those of the joint meetings of the British and American Associations for the Advencement of Science, or some of the international congresses held in America. The number in attendance on the Geological Society of America was about 115, the largest meeting hitherto having been 80. Section E of the Association and the Geological Society held joint meetings, the papers listed being more than 90. Most of these were presented in the meeting room of the U. S. Geological Survey, but a series of papers relating to the West Indies were given in the Columbian University. An illustrated popular lecture on the volcanic phenomena of Mont Pelée was given by Prof. I. C. Russell, and the retiring address of president Winchell was given in the New Willard hotel. Mr. John Hays Hammond gave a popular lecture at the Lafayette Opera House, on "King Solomon's mines, or the mines of Ophir." The week was diversified with numerous dinners, luncheons and receptions and with visits to various public buildings.

Owing to the crowded condition of the meetings, several of the sections and affiliated societies suffered from the friction and the duplication of the machinery of administration, but it was only for the relief of Section E that the Council of the Association took general action, in the adoption of the following resolution :

Resolved, That Section E is hereby authorized to suspend its scientific program of the reading of papers at any winter meeting when the Geological Society of America meets in conjunction with the Association; *provided*, that the Geological Society includes in its program the papers of worthy character offered by members of the Section who are not fellows of the Society.

The Association, however, requires each Section to hold at least one afternoon meeting, during each general meeting of the Association when a program of general interest shall be presented. At such meeting it is likely that in future the address of the retiring chairman of Section E will be heard.

The new president of the Geological Society is S. F. Emmons, Washington, and the vice-president, Section E, is I. C. Russell, Ann Arbor. The next annual meeting will be convocation week 1903-04, at St. Louis. The new president of the American Association is Carroll D. Wright, Washington.



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GEOLOGY OF THE JEMEZ—ALBUQUERQUE REGION, NEW MEXICO.

By ALBERT B. REAGAN.

PLATES IV-XII.

CONTENTS.

	Page.
General description	68
History	69
Structure.	
Nature of Rocks	69
General sections	70
Nacimiento Mountains	71
Cochiti Range	72
The Plateau	73
The San Dia Mountains	73
Sedimentary Deposits.	
Carboniferous	73
The Permian	74
The Red Beds	74
Age of the Red Beds	76
The Gypsum Series	77
Age of the Gypsum	78
The Cretaceous Strata	78
The Fox Hills	79
The Fort Union Beds	80
The Puerco Marls	81
The Tertiary Strata	83
The Eocene Formation	83
The Pliocene Strata	85
The Jemez Marls	85
The Albuquerque Marls	86
The Pleistocene Deposits	86
Jack Rabbit Valley	86
Vallecieto Viejo	86
Placita Marl	87
Deposits of the Jemez Valley	88
The Rio Grande Marls	89
Age of the Rio Grande Deposits	89
Resume of the Stratigraphy of the Region	90
Geography and Physiography.	
Rivers	91
The Rio Grande	91
Age of the Rio Grande	92
The Rio Puerco	92
The Jemez River	92
Age of the Jemez River	93
Tributaries of Jemez River at the North	93

Salt River..... 94
Lower Jemez River..... 94
Mountains..... 95
San Dia Mountains..... 95
Jemez Mountains.. 95
Villages and Cities..... 95
General Survey..... 96
Sand Dunes..... 97
Mt. Cabizon..... 97
Mt. Pelado..... 98
Medicinal Springs..... 98
Phillip's Springs..... 98
San Isidro Springs..... 99
Indian Springs..... 99
Jemez Hot Springs..... 100
The Soda Dam..... 101
The Sulphurs..... 102
General Survey of Springs..... 102
The Tufa Flows..... 103
Age of the Tufa of the Jemez mountain District..... 103
The Basaltic Volcanoes and the Lavas outpoured by Them 104
The Rio Puerco Series..... 104
The Rio Grande Series..... 104
The Albuquerque Valcanoes..... 105
The **Bernalillo** Volcanoes..... 105
The San Felipe Volcanoes..... 105
Date of Eruption of the Rio Grande Series..... 106
Economics.
Climate..... 108
Soil..... 108
Irrigation..... 109
Mining..... 110
Mineral Resources..... 110
Coal..... 110
Gypsum..... 110
Gold, Silver and Copper..... 110
Placer..... 110

The following pages are derived from studies carried on at intervals during the writer's stay at Jemez Pueblo as government farmer. While there he took work by correspondence in the University of New Mexico; and the original reports, on which this paper is based, were submitted, for the most part, to Dr. C. L. Herrick, then president of that university.

In submitting this paper the writer gratefully acknowledges the assistance of professor G. B. Haggett, who accompanied him on several of the expeditions upon which this paper rests and whose photographs are here used by his permission. He wishes also to acknowledge his special indebtedness to both Dr. C. L. Herrick for the valuable aid rendered him when studying the region, and also to Drs. J. W. Beede and F. V. Marsters for their personal aid while the paper was being written.

General Description.

This region is in northwestern New Mexico between longitude 106° 20′ and 107° west, and latitude 35° and 36° north. Roughly speaking, it is a triangle with its apex toward the south. It is bounded on the southeast by the San Dia mountains, on the southwest by the Rio Puerco, and on the north by the upper plateau of the Jemez mountains. Its principal river is the Rio Grande, and its commercial center is Albuquerque. The Santa Fe railroad enters this section at the northeast near Thornton, and passes through it just to the east of the Rio Grande to Albuquerque. At this point the road branches, one branch of the system going to El Paso, Texas, the other, the Atlantic and Pacific, to California and the Pacific coast.

History.

Some parts of this section have been visited by geologists in the last twenty-seven years. Professor E. D. Cope visited the region lying between Algodones and Placita in 1875; and while there he found Pleistocene deposits overlying Tertiary and Cretaceous rock. In the following year he also visited the Puerco marls at the source of the Rio Puerco. Dr. C. L. Herrick has described at considerable length, the southern portion of the section in volume I of the Bulletins of the University of New Mexico. Among his subjects treated in that bulletin, which will receive notice here, are the "Pleistocene marls" (here called the Zia marls) and "The Rio Grande loess." He also describes some of the volcanoes of this region in the same bulletin.[1]* A further discussion of the above citations will be given when the respective areas concerned are considered.

Structure.

Nature of rocks.—The rocks of this area are intrusive, eruptive, and sedimentary. The intrusive rocks are the cores of the mountains of Jemez and San Dia; and the dikes throughout the entire region. They are granites, porphyries, gneisses, et cetera.

The eruptive rocks are the volcanic plugs, lavas, and tuffs. The lavas are basalt, trachyte, and rhyolyte. Obsidian also occurs in large quantities on the Jemez plateau. All the eruptive rocks, except the trachyte-rhyolyte lavas, will receive attention under the subject of "Geography and Physiography."

* The numerals thus used (1) refer to references at the close of this paper.

The trachyte-rhyolyte lavas underlie the tufa in the vicinity of Pelado and the Valle Grande country. Their entire thickness was not ascertained, though 400 feet of these lavas, in vertical section, were measured to the east of the Jemez river in the vicinity of the Jemez sawmill.

The sedimentary rocks are the country rocks of nearly the entire region, where not covered with lava. They were laid down in the seas and lakes that surrounded the islands which now form the high mountains of San Dia and Jemez. These deposits date back well into the Carboniferous, and continue almost without break to recent times.

General sections.—In order to give an idea of the general stratigraphy of the region under consideration, three general sections will be given: (1) extending from Jemez peak in the Nacimiento mountains to the fault at the foot of the San Dias; (2) from the same peak south to the Rio Puerco; (3) from La Vantana on the Rio Puerco to Tejon, north of the San Dia mountains.

In passing from Jemez peak along the first section, we traverse four miles of the Jemez-Nacimiento mountain core of granite and red orthoclase; then over Carboniferous, Permian, and Red Beds. The three latter are conformable and dip at a steep angle toward the southeast away from the mountains. Beyond the Red Beds is a small patch of Pliocene one-half mile in width, with strata dipping gently to the north. Pleistocene is then encountered, and continues with strata nearly horizontal for about two miles, when Pliestocene recurs with strata dipping slightly to the northwest. These strata form the east bank of the Jemez river at San Isidro. After crossing this deposit we again come upon the horizontal beds of the Pleistocene of the Jemez river on the east side of the big bend. After crossing this flood plain, about two miles in width, Cretaceous strata crop out. These rocks dip toward the southeast. On climbing up the divide, we enter upon the Zia marls which continue to the Rio Grande, a distance of twenty-eight miles. The alluvium of the Rio Grande valley extends from the west bank of this river to the foot of the San Dias, a distance of about twenty miles.

The second section from Jemez peak south to the Rio Puerco presents the following surface exposures: three miles of granite, seven miles of Red Bed strata, dipping at a great

angle to the southwest, followed by a mile of Pleistocene in the Salt River gap. After crossing this gap, there are three miles of gypsum-capped Jurassic rock, with strata dipping toward the southeast at a considerable angle, followed by Cretaceous, which extends for two miles or thereabouts. The area here is much broken. The rocks all dip toward the southeast. At the south edge of the Cretaceous area the Fort Union coal is brought to the surface by a succession of minor faults and a major fault. The Fort Union is exposed for nearly a mile. Then the Puerco clays are to be climbed over for about a half-mile. On tracing the top of the divide to the south of the coal fields, the strata overlying the Zia mesa are the Zia marls. These continue in unbroken series to the Rio Puerco.

Traversing the section from La Vantana to Tejon, we cross the following country rock: from La Vantana for a distance of six miles the strata are Puerco; to the southeast of this is a small gypsum patch (Jurassic) probably a mile in width. This gypsum together with the above mentioned Puerco dips west at a considerable angle. Leaving the gypsum, the exposed granite core of the Nacimiento mountains, some six miles in width, is crossed. To the east of these mountains the country rock is Carboniferous, the strata of which dip at a steep angle toward the southeast. Crossing the Jemez river at Cañon, the exposed rocks for three miles are Red Beds, followed by Pleistocene and Eocene respectively. The Eocene continues to and beyond the Rio Grande for a distance of twenty miles; but throughout the greater part of this distance it is overlaid with lava flows. From the Rio Grande east of south, for seven miles, the country is Pleistocene, Tertiary or Cretaceous, depending upon the amount of erosion. Beyond this point we pass over about a quarter of a mile of Carboniferous rocks; and then one mile to Tejon, over Red Beds strata which dip at an angle of 45° to the east.

Nacimiento Mountains.—The Nacimiento mountains, the west extension of the Jemez group of mountains, have a core of red feldspathic porphyry (commonly called granite) and red orthoclace. The latter occupies a peripheral position and in one instance extends to the east of the main range for a short distance. A spur of eruptive granite also extends south-

east from the main axis. This dike of granite separates the two Red Bed mesas, which dip in opposing directions from it. Another dike crosses the country in an east and west direction on a line with the Soda Dam, the waters of which are forced to the surface by the dike. The dike is 800 feet wide, and protrudes up through the Carboniferous and Red Beds strata. The rocks of this dike are commonly called granite; but in fact they are eruptive gneiss of the protogine type. The main ridge of the Nacimiento mountains is one solid mass of porphyry of the true Rocky Mountain axis (Cope), and extends in a north and south direction for many miles. It was once covered with sedimentary deposits; but since the uplift these deposits have been removed by erosion so that the entire crest is composed of porphyry. The dipping of all the sedimentary deposits on the flanks from the main ridge indicates that the ridge is intrusive. The successive decrease in the dips of the sedimentaries suggests that the whole area has been subjected to uplift at different periods. This will be mentioned later. The absence of the Carboniferous at the south and also at the west indicates that this extension of the Jemez mountains was partly at least the result of a faulting on the western side. The age of the uplifting seems to be established, because at the south of the ridge here the Carboniferous is wanting, Red Beds are deposited against the granite walls, and rest upon a granite floor which is a part of the mountain's ridge. As I say, this seems to indicate the age of these mountains and that it is as early as the beginning of the Carboniferous; but data are wanting, at this time, to explain the apparent relations referred to.

Cochiti Range.—In the Cochiti range from Pelado east to Peralta canyon and the mines of the Cochiti gold mining company, the core is granite, the same as that of the Nacimiento mountains. On top of this is gneiss, over which are volcanic rocks and tufas where they have not been removed. From the top of the divide east of Pelado along the western side of this projection the exposed rock is intrusive porphyry of the labradoryte type. At the south occur the basaltic lava flows which have covered the area so that it is difficult to tell what the underlying rock is. At a point five miles northeast of Valleciete Viejo a fault exposes Eocene strata. This fault continues for

many miles in a north and south direction; and often shows a thousand feet of displacement. This uplifted tongue of lava-capped Eocene strata is the southern prolongation of the Cochiti range.

At no place where examined did rocks older than Tertiary lie upon the flank of this range; but it is said that on the east side, which part was not visited, Cretaceous and even earlier stratified rocks are found. The faulting of the Eocene on the south of the range and the elevating of the same, indicates that these mountains were re-elevated after the close of that epoch.

The Plateau.—Turning now to the main plateau of the Jemez mountains, the writer will state that he has visited but little of it. This plateau is often spoken of as the basaltic plateau, but the basalt seems to be more on the flanks of the mountain than on the plateau. The central portion of the plateau, like that of its extended rim, is feldspathic porphyry (granite). On this, in the Valle Grande country, there is at least 400 feet of rhyolyte in situ over which is tufa varying in thickness from forty to a hundred and forty feet in its original position. Pelada is the culminating point in these mountains.

The San Dia Mountains.—To use the words of professor Jenks[2] "The central core or axis of the San Dias is generally granite, a metamorphic or changed rock of Archean age." The San Dias are everywhere capped with Carboniferous strata.

Sedimentary Deposits.

The sedimentary deposits of this region, beginning with the Carboniferous, are:

Carboniferous.

There are two Carboniferous districts; one in the San Dia uplift, the other in the arch of the Jemez uplift. The former was not examined closely by the writer, except at a point north of Tejon where several specimens of *Productus punctatus* were found. The Carboniferous of the Jemez mountains is patchy. The patches flank the mountains within the arch from near Jamez peak to the vicinity of the soda dam. They have an altitude of about 7000 feet at their upper terminus. The formation in the southern patch reaches as far east

as the Canyon de Los Jemez. On the western side of this patch the strata dip southeast at an angle of 40°, and on its eastern terminus west at a still greater angle. The rocks of this age exposed in the Jemez arch are limestone and shale; Carboniferous shale appears in the lowest exposed strata. The thickness of all the strata exposed is about 700 feet. The rocks are upper Carboniferous as is attested by their fossils. Among the fossils identified by the writer and by Dr. C. L. Herrick are: *Spirifer striatus, Seminula argentia* (*Athyris subtilita*), *Productus mesialis, P. punctatus* and *P. nebrascensis,* and *Myalina subquadrata.*

The Permian.

Resting conformably upon the Carboniferous strata are from 100 to 200 feet of reddish brown calcareous sandstone and shale. This area is divided into two parts by the granite dike which extends to the southeast through this region from the south terminus of the Nacimiento mountains. The strata of the Permian on the one side of this dike dips southeast and on the other side toward the southwest, that is, away from the dike. That these strata are Permian is beyond question. Many Permian fossils were found by the writer, among which was *Pseudomonitis hawni.* To be sure that the writer was not mistaken in his decision, he submitted many of the fossils of these beds to Dr. C. L. Herrick with the result that his identification was confirmed. The strata here described are Permian.

The Red Beds.—Immediately overlying the known Permian and conformable with it are blood red sandstones and shales fading out to white at the surface of the mesa. The rocks are so red that they reflect the rays of the sun, and in the morning the reflected red light from these red mesas shines in at the west windows of the houses at Jemez, a mile away and gives everything a peculiar appearance. 1600 feet of these Red Bed strata are exposed here. The area of the two mesas, previously mentioned, aggregates about thirty-seven square miles. Besides these two areas to the west of Jemez Pueblo and south of the Nacimiento mountains, a triangular area occupies the space between the canyons Guadalupe and San Diego from Canyon de Los Jemez on the south to near the top of the Jemez plateau on the north. Another area occupies

nearly the whole space to the south of [illegible] between [illegible] Diego canyon and [illegible] creek, nearly as far south as Jemez. There is another small patch to the southeast of [illegible] creek south of [illegible]. [illegible] strata are exposed here in vertical section [illegible] feet, but as the strata dip at a considerable angle toward the southeast their true thickness must be less.

Another area appears to the south of [illegible] canyon [illegible] east of Jemez with strata dipping east at an angle of [illegible]. [illegible] narrow ridge now remains of these [illegible]. [illegible] patch is exposed several miles southeast [illegible] but the weather shows little of it. The [illegible] region [illegible] extends in a northeast direction [illegible] east to the west [illegible] east [illegible] beds are [illegible] is [illegible] seems to be [illegible] is the small area east [illegible] in the [illegible] at angle of 45° [illegible] mentioned [illegible] vesicular limestone [illegible] feet of light colored sandstone [illegible] a yellow limestone [illegible] about 500 feet [illegible] the upper Cretaceous [illegible] But it is the opinion [illegible] beds seem, since the [illegible] with the underlying [illegible] possible that they are [illegible] sea till after the Jemez [illegible] would account for [illegible] able with the [illegible] Cretaceous because [illegible] Cretaceous at [illegible] these rocks [illegible] sandstones are [illegible] the east, separating [illegible] is the same in strike [illegible]

west by Cope, Newberry and Marcou and called Jurassic by them. The limestone and sandstone above mentioned therefore can not be Cretaceous and undelie the Jurassic; but must be of the same age as the Red Beds with which they form an unbroken series.

Age of the Red Beds.—The Red Beds of the west, on account of their being non-fossiliferous and red in color, have been called Trias; and even the Red Beds flanking the Jemez plateau at the Rio Chama and in the vicinity of Nacimiento have been called Trias by Cope for the same reason. Others have called them Carboniferous. They are conformable with the known Permian at Jemez; and this Permian, in turn, lies conformable on the Carboniferous. They can not therefore be Carboniferous. There is no positive evidence that they are Triassic, though Cope, Newberry and Marcou referred them to that system. In speaking of the formation at Cañon Caugilon just north of the Jemez mountains, Cope says[4]: "The sandstone of the north half of Canyon Caugilon is Cretaceous number 1, thickness 800 feet. Below it is the gypsum usually referred to the Jurassic, 50 feet, and doubtless inseparable from the brilliantly colored beds below (400 feet) which are stated by Hayden to be Jurassic beds. The hard sandstone underlying these is the upper member of the beds that correspond to Trias of the Colorado section."

Since the survey from which Cope made his report was finished, many geologists have investigated the Red Beds in different parts of the west and have demonstrated that they can no longer be called Trias simply because they are red and non-fossiliferous. Fossils have been found in some localities which show that the lower portions, at least, of the Red Beds are Permian.

In a letter to the writer bearing the date of January 25th, 1900, Dr. C. L. Herrick says: "We have been fortunate enough to find a good series of Permian fossils in the lower Red Beds of southern New Mexico." The Red Beds in Texas and western Kansas that were once called Trias are now conceded to be Permian, and the finding of Permian fossils by Dr. Herrick in the Red Beds of New Mexico is evidence of the Permian age of these rocks also.

The Gypsum Series.—The gypsum series consists of dark blood red, soft sandstones and variegated shales, covered in all cases where exposed, with a gypsum cap. These rocks most always rest upon the Red Beds, above mentioned; but the writer was not able to determine whether they were conformable with the Red Beds or not. They, however, seem to be conformable.

These series only occur in patches. One large area is known as Mesa Blanco. Another area is just across Salt river opposite Mesa Blanco. Several exposures lie west of the Nacimiento mountains. A very small area is exposed about six miles southeast of Jemez Pubelo north of the Jemez-Santa Fé wagon road. Other areas are exposed northeast of Tejon.

Mesa Blanco is situated three miles southwest of the Mexican village of San Isidro south of Salt river. Its northern border is a fault scarp 600 feet in hight. This scarp faces Salt river which rests on the downfaulted portion to the north of the fault line. Of this 600 feet the lower 550 feet are composed of characteristic dark blood red sandstones and variegated shales of the series. The upper fifty feet are gypsum. The northern border of Mesa Blanco is eight miles in length. It tapers to a point at the south. Its area is about half a township. Its strata dip to the southeast at an angle of 40°.

Just to the west of this mesa, and standing against it, is a ridge of this series which extends twelve miles in a north and south direction. This ridge averages about a half mile in width, though in many places it does not exceed 100 yards, notwithstanding that, its altitude is most always from 300 to 500 feet greater than that of the surrounding strata. The gypsum is on the western slope.. It dips west at an angle exceeding 70°. This ridge is the southern extension of the Nacimiento mountain uplift.

The gypsum area north of Salt river and opposite Mesa Blanco, occupies a space of less than forty acres. It is surrounded on all sides, except the west, by Pleistocene and Tertiary deposits. The rock to the west is the Red Beds series from which it is separated by a fault. The strata of this area dip south and a little east at an angle of 40°. The uppermost exposed rock is a thirty foot gypsum stratum. This gypsum is of good quality; and is used by the Mexicans and Indians

for various purposes. They burn it and then whitewash their houses with it.

Several gypsum-capped patches, each of small area, flank the Nacimiento mountains on the west. They were islands or isthmuses in Cretaceous time, as they are all entirely or nearly entirely surrounded with Cretaceous deposits.

The gypsum-capped area southeast of Jemez Pueblo is a still smaller one, not more than five acres being exposed. It is surrounded on all sides by Tertiary beds, which indicate that it remained an island even to the close of the Tertiary period. The strata of this area dip northeast.

To the northeast of Tejon there are several gypsum patches. They all occupy valley positions, all are small, and the strata of each dip east at an angle of 40°. They may cap the Red Beds series there, but the strata are too much broken to give anything definite on the subject. The easternmost of these patches dips under the Cretaceous, which will receive attention later.

Age of the Gypsum.—The gypsum series here described occupies a position between the Red Beds and the Cretaceous. By some geologists it has been correlated with the Red Beds, and the whole called Juratrias. By others it has been designated as the gypsum series and left at that. But Cope, who visited the section north of the Jemez plateau, has called it Jurassic; and in speaking of the gypsum series at Canyon Caugilon, he says: "The gypsum is that usually referred to the Jurassic—...and doubtless inseparable from the brilliantly colored beds below which are stated by Hayden to be Jurassic."*

The Cretaceous Strata.

In this paper the writer will consider the Fort Union beds and the Puerco marls as Cretaceous for reasons which will be given later. He will then have west of the Nacimiento mountains 1000 feet of Puerco marls at the head waters of Salt river. Just south of these marls the Fox Hills comes in, and continues from the Jemez group of mountains near Jemez peak in a curve to a point below Cabizon on the east side of the Rio Puerco. They also extend west of that river farther than was visited. They are covered with later deposits west of Cabizon. South of the Fox Hills east of Cab-

izon, the Puerco again appears; but its thickness is not great. This Puerco also occupies the valley of Salt River from near Ojo del Espiritu Santo to Mesa Blanco. Beneath the Puerco east of Cabizon is the Fort Union formation. It is also seen in places to the west of the Rio Puerco. It is exposed, for the most part, along faults. The principal exposure is along the fault both north and south of the Fox Hills. It extends from the village of Nacimiento in a southerly direction beyond Mesa Blanco. Passing south of the Jemez river, orange colored Cretaceous sandstones and shales overlie Mesa Blanco at the south; and extend east as an outcrop along the Zia mesa break, till their dipping strata pass out of sight beneath the Pliocene deposits of the Jemez valley. On the Rio Grande the Cretaceous orange beds appear along the tributaries of that river which come in from the southeast from the vicinity of Tejon. These beds are exposed in the bottoms of the canyons only. East of Tejon another Cretaceous area appears superimposed upon the Jurassic series, as we have already noticed. This area extends east and north farther than was visited. Its strata are repeatedly faulted, thus exposing the same strata in vertical section time after time. It is coal-bearing, but the beds are not thick. The coal is bituminous, but poor in quality. It is mined in several places. On inquiry it was learned that farther northeast the coal seams are thicker, and that the coal is of better quality. It was furthermore learned that the carbonaceous slates above the coal seams are not so thick there. This cretaceous is Laramie or Fort Union.

Considering the Cretaceous west and southwest of the Nacimiento mountains more in detail, we will treat them in their order of deposition as follows: Fox Hills, Fort Union and Puerco marls.

The Fox Hills.—As has been previously stated the Fox Hills extends from near the Jemez group of mountains west of Jemez peak to the Rio Puerco, and then south down that river. It was a ridge in Fort Union and Puerco times, which extended west as a peninsula from the Nacimiento mountains to a cretaceous area lying beyond. The Fox Hills dips west from the Nacimiento mountains in the peninsula part; but, after passing south of Cabizon, it dips northeast to the east of the Rio Puerco, and on the west side of that river it dips south-

west. In the canyon of the Puerco river, about five miles south of Cabizon, 800 feet of strata are exposed in vertical section. The rocks of this exposure are orange colored sandstones and dark fissile shales, except the lower 150 feet which are gypsiferous in structure and probably Jurassic in age.

The Fort Union Beds.—The group of rocks here designated as Fort Union lie conformably on the Fox Hills. They are found both to the north and also to the south of the eastern extension of the Fox Hills. They are known as the coal group, and are 500 feet in thickness. They show a predominance of soft yellow sandstone, interbedded with clays and sandy shales. They contain strata of brown coal which are freely exposed in perpendicular walls of the mesas. The coal seams in the Jemez coal fields south of Mesa Blanco, near San Isidro, are from two to twelve feet in thickness; and along one fault in this coal area, seventy feet of coal are exposed in one view. In examining these coal fields it was observed that in many instances the strata had been destroyed by fire; and, the coal being burned out, the roofs had caved in by a succession of faulting or had collapsed under pressure. That the destroying agent was fire is attested not only by the clay accompanying the seams being transformed into brick, but also by masses of slag composed of the silicates of iron and aluminum. This coal is bituminous and is Fort Union or Laramie. It is very brittle, somewhat laminated, and of dull luster.

In speaking of the coal outcrop near Nacimiento, Mr. Loew in the U. S. Geographic Surveys of the Territories, says:

"The strata of brown coal are freely exposed in the perpendicular walls of the mesas, and are accompanied by shales, slate, clay and sandstone. Their thickness varies from six inches to eight feet. In some instances the strata have been partly destroyed and undoubtedly by fire, as evidenced not only of the accompanying clay being burned to brick but also by heaps of slag composed of silicates of iron and aluminum...It is bituminous and Cretaceous, not coking; very brittle, somewhat laminated, luster dull."[5]

Had this same writer visited the coal fields southwest of San Isidro to the south of Mesa Blanco, he could have described them with exactly the same words that he has used in describing the coal outcrop at Nacimiento. The coal is identical, is Cretaceous and Fort Union or Leramie.

The Puerco Marls.—In examining the Jemez-Albuquerque geological region described in these pages, several patches of grey, greenish and pinkish marls were noticed. One patch is east and southeast of Mesa Blanco; a second is in the valley of Salt river, north of Mesa Blanco and south of the spring Ojo del Espiritu Santo; a third area lies between the top of the divide west of Salt river and Cabizon; and a fourth, as we have seen, is the country rock from the head waters of Salt river north to the head waters of the Rio Puerco. These pinkish deposits were the puzzle of the whole geological research. Their stratigraphic position was readily determined to be at the top of the Fort Union; but where the Fort Union is wanting they repose directly upon the Fox Hills; and in either of the above cases, they seem to be conformable with the formation they overlie except in the first case mentioned—the area to the east of Mesa Blanco. This formation, in part at least, there overlies the Jurassic.

To give these marls a position geologically is a difficult task. In places as has been stated, they lie apparently conformable on the Fox Hills, at other places on the Fort Union, and at still others unconformable on the Jurassic. Their being practically nonfossiliferous also makes the task the more difficult. On their geological position geologists differ widely.

In speaking of the geological position that the Puerco marls occupy Dr. Smith says:

"The Puerco formation is located in northwestern New Mexico at the head waters of the Rio Puerco.... The rocks of this formation consist of sandstone and grey and green marls. The formation is thus characterized by Wortman: 'The thickness of the beds is roughly estimated at 800 to 1000 feet; and as far as can be observed, they lie conformably on the Laramie.' "[6]

Concerning the same formation and its geological position Endlich says:

"It is entirely conformable with the Fox Hills,... From the evidence obtained by professor Cope farther south [at Nacimiento on the Rio Puerco] and the negative evidence in our own district, there is scarcely any doubt but that the position assigned to their group at the base of the Tertiary is a cor-

rect one. Room is left for doubt only by the absence of fossils."[7]

We will now return to professor Cope's report on these marls.

In discussing these marls, Cope says: "The fauna of this formation is different from that of the other Eocenes in the presence of a saurian Champsosaurus, which is characteristic of the Laramie Cretaceous, and of marsupial mammals (*Ptilodus* and *Calopsalis*) which are remains of a type otherwise known as Jurassic."[8]

Cope again says:

"As already remarked, the Puerco marls may belong to the Eocene series in view of their strict conformability to the superincumbent rock of that age. But they may represent the Fort Union or lignite beds of the Upper Missouri some of whose strata they resemble in color and consistence. They contain no lignite nor coal, although their occasional black color may be due to a small amount of carbonaceous matter."[9*]

Where to place these marls is a more difficult proposition now that we have read the conclusions and the remarks of the above geologists. Dr. Smith says that they lie conformably on the Laramie. Endlich states that they are conformable with the Fox Hills, and should be assigned a position at the base of the Tertiary, room, he says, only being left for doubt by the absence of fossils. Cope finds fossils and finds them to be of Laramie or earlier age, and concludes that they may represent the Fort Union beds which they resemble in color and consistence.

Had Cope gone farther south, or a little farther east in his explorations, he would have found that these beds contain more and more carbonaceous matter as lower portions of the series are exposed till they grade insensibly into the Fort Union brown coal series, observed by Mr. Oscar Loew near Nacimiento; but, as Mr. Cope states in his report, "The expedition was abandoned at this point" and he said his party went to the San Juan country, thus leaving the position of these marls unsettled.

To consider the position of these marls further, where the Fort Union (Laramie) is wanting they lie apparently conformable upon the Fox Hills; but do not grade into them.

But in all cases in which they overlie the Fort Union, they grade insensibly into it. This was the case throughout the entire area examined by the writer; and the whole was called Fort Union by him while in the field. They therefore seem to be upper Fort Union and represent a transition between the Fort Union and the Tertiary. The fossils found by Cope (see above) seem to bear out this conclusion. They seem to be the top of the Cretaceous rather than the base of the Tertiary.

The Tertiary Strata.

On leaving the mountain districts, except west of the Nacimiento mountains, the Tertiary is the prevailing country rock where it is not covered with lava or Pleistocene deposits. Throughout its entire area it is fissured and faulted; the rivers of the country in their process of base leveling have chiseled their channels deep into it. The great dike and the Rio Grande series of volcanoes penetrate its surface; and lava flows, covering hundreds of square miles, are superimposed on it. The dip of the whole formation, where dip is noticeable, is away from the mountains at an angle of about 15°, except at Jemez Pueblo where in the valley the strata dip north. This Tertiary is a "bad land" country; where the lava is superimposed on it it is of the "mal pais" type; and where the lava is wanting, especially along the break lines, "mauvaisses terres."

Having mentioned the Tertiary in a general way, we will proceed to consider it more in detail. Two epochs of the Tertiary are represented here, the Eocene and the Pliocene.

The Eocene Formation.—The Eocene formation at one time covered the greater part of this region, but a faulting and folding of the strata in different parts left basins on a grand scale, which in Pliocene times were lakes. The Eocene country rock now is the entire Zia mesa between the Rio Grande and the Rio Puerco north to the Jemez river and Mesa Blanco and west of a point below Cabizon. The Eocene also underlies the great lava sheet to the west of San Felipe and also the lava-sheet of the tongue-shaped mesa which projects south from the Cochiti range. The thickness of this formation was not ascertained, though 1000 feet of it in vertical section are exposed along the west break of the tongue-shaped mesa above mentioned. The strata throughout are soft red and gray sandstones,

which remain nearly horizontal, except in the case of the Zia mesa where they dip, for the greater part, southeast. The latter mesa is without lava deposit, except near Albuquerque and Ysleta; but instead is capped with a marl which henceforth shall be known as the Zia marl. This marl is a bluish yellow. Its thickness is from five to forty feet except at the north to the west of Mesa Blanco where it thins out to an edge.

If geologists who have visited this formation along the Rio Grande, were agreed we would give their conclusions and close the remarks on this subject: But, since one calls the formation Cretaceous, and another calls the lower strata Cretaceous and the upper stratum "Pleistocene?,"[10] and the writer's opinion differs from either, a further discussion is necessary. No fossils, so far as the writer knows, have been found in these marls. Therefore, only on stratigraphical position can their horizon be determined. But along this line evidence is not wanting.

The Fort Union coal beds and the Puerco marls, the last of the Cretaceous series, underlie a thousand feet of this formation at the north along the Zia mesa break and south of Mesa Blanco on west to a point below Cabizon. It, therefore, can not be Cretaceous and overlie the above formations. Again, the marl cap is conformable with the grey and red strata beneath, and these in turn lie conformable on the Puerco. In no place in New Mexico has Pleistocene been found lying conformably on the Eocene. Not even in a single instance has it been found conformable on the Pliocene. The Pleistocene found by Cope at Placita lies unconformably on the Pliocene and Cretaceous. This marl cap, therefore, can not be Pleistocene. Consequently, inasmuch as the Pliocene, as we shall see later, lies unconformable upon it, this formation must be Eocene.

The next thing to explain is why the same formation, the rock of the same age, to the one side of the Jemez river has a thick marl stratum as its top layer, and on the other side this marl stratum is wanting.

As we have already noticed, practically all the strata of this region dip away from the Jemez mountains; and as we proceed south from Jemez peak we pass over successive formations, all conformable, till the marl stratum at the top of the Zia

mesa is reached thus indicating that the Nacimiento mountains here have been gradually elevated at the south throughout many geological ages. Now, in Eocene time these mountains, in their upward movement, were continually pushing the Tertiary lake shore farther south, till the northern limit of this lake was about on a line with Mesa Blanco and the Jemez river in its lower course when the marl stratum of the Zia mesa was deposited; this marl then would not appear to the north of that river. Proof that this interpretation is a correct one is shown by the fact that the marl extends west of Mesa Blanco, as we have seen, to the Rio Puerco below Capizon; but to the north of this line it tapers out to a thin edge and disappears.

The Pliocene Strata.—At the close of Eocene epoch, there was a faulting and breaking up of the country on a grand scale. The great Eocene lake (sea) was obliterated; and in its stead all the troughs made by the faulting and shifting of the strata became fresh water lakes. One of these lakes occupied the area between the Zia mesa at the south and the Red Bed and Carboniferous mesa north and west of Jemez Pueblo, covering an area of more than 80 square miles. Another large lake occupied the Rio Grande valley from the Eocene bluffs west of the present river east to the foot of the San Dias.

The serata of this formation are alternating softer and harder calcareous sandstones and conglomerates varying from white to deep green and light rufous.

The Jemez Marls.—This series in the Jemez valley is always capped with a conglomerate stratum now considerably cut up and eroded. The marls are a lighter color and also much softer than the marls in the Eocene formation, just described. The Indians at Jemez call these marls "Dafwa" and use them for various purposes. The marl is pulverized and with it a whitewashing solution is prepared, which is more desirable than the standard material prepared from gypsum. The writer will adopt the Indian name Jemez for these marls. The Jemez marls are 250 feet in thickness on the bluffs, in the vicinity of Jemez; but in the valley of the Jemez their thickness is less than a hundred feet. They rest upon the strata of various formations ranging from Carboniferous to Eocene.

They are usually horizontal, but west of Jemez Pueblo, dip slightly to the north. Their bluff formations weather down into cones and castled buttes. They give a picturesqueness to the valley. Pleistocene deposits cover these in the valley.

The Albuquerque Marls.—The Pliocene rocks in the Rio Grande embayment which are identical with the Jemez marls, just described, will here be called the Albuquerque marls. These marls are a continuation of the Santa Fe marls of Cope, a part of which was identified by him when at Algodones in the seventies. It also corresponds to the Loup Fork epoch (Tertiary) according to that geologist. [12] They are 350 feet thick at Albuquerque but thin out toward the San Dias. The upper stratum except the last, is a conglomerate series, the last is 5 to 10 feet of a curious yellowish white marl. The composition of this marl is: SiO_2, 26.53; Fe_2O_3, 1.20; $CaCo_3$, 64.47.[11]

The Albuquerque marls are covered for the most part with later deposits, usually not more than ten feet in thickness. They will be mentioned later under "Pliocene Deposits."

The Pleistocene Deposits.

Pleistocene deposits are found in patches throughout the entire area visited. One small patch is situated at the foot and south of the Nacimiento mountains. Another patch occupies the upper valley of Vallecieto creek at Vallecieto Viejo. Several patches are found between the hills on the road to Tejon and Placita near the Indian village of San Felipe. A large area occupies the inner valley of the Jemez river from Cañon de los Jemez to the Bernalillo volcanoes, and extends more than eight miles up Salt river from its confluence with the Jemez. A still larger area is found in the inner valley of the Rio Grande for many miles both above and below Albuquerque. These latter mentioned deposits may be designated as the "Rio Grande Marl."

Jack Rabbit Valley.—The Pleistocene area at the foot of the Nacimiento mountains is about the size of two sections of land. It is the site of a Pliestocene lake. Its deposits are adobe clay and gravel overlying a granite floor. This area is called Jack Rabbit valley.

Vallecieto Viejo.—In the Vallecieto Viejo area the Pleistocene covers a half a township or more. The underlying strata of this deposit are cross bedded sands and gravels, some four

to ten feet in thickness. The upper strata are adobe. The line of thickest deposits lies in a north and south direction and conforms very nearly to the present course of the Vallecieto creek which runs through the area. It tapers out to a thin edge to the west in less than a quarter of a mile while to the east it extends for more than two miles. The eastern margin lies on the Tertiary, the middle or lowest on the Cretaceous, and the western margin on the Red Beds. In Pleistocene times this area was a lake, and was initiated by the shifting of the strata to the south and east of the Red Beds hogback at the close of the Tertiary, and remained laked till a channel was cut along the fault line to the southwest, thus giving it an outlet to the Jemez river. Along this fault the river has cut a deep channel through the solid Red Beds to get an outlet, although the strata to the southeast of the lake is but partly lithified sands and clays. This shows that faulting aided in locating the present channel. There is also strong evidence to show that the basalt eruptions took place in Post Tertiary times, because the lava flowed into the lake and at the eastern margin is interbedded with the Pleistocene deposits here described.

The Placita Marl.—The Pleistocene deposits between San Felipe and Placita are found in the depressions between the rolling hills. In places they overlie the Tertiary, at others, the Cretaceous, and near Tejon, the Carboniferous. On the east they are closed in by a spur of Red Beds which projects northeastward from the foot of the San Dias. The above indicates that there was an erosive period after the close of the Tertiary, a lost record, before the Pleistocene deposits were laid down. These deposits are cross bedded promiscuously mixed sands and gravels overlaid with thick deposit of adobe clay.

Dr. Cope visited these deposits and in his remarks about them, says:

"A section carried across from Algodones (near San Felipe) on the Rio Grande to the San Dia mountains through the village and creek of Placita, gave the following results: The road winds among and ascends for several miles mesas of coarse Tertiary gravel and cobblestones until it reached a wide plateau, from which the mountains rise on the east. This tract is traversed by Placita creek and its tributary arroyas which furnish interesting sections. From these it appears that the

greater part of the plateau consists of the yellow, muddy shales and sandstones of Cretaceous number I. They form the bottoms and sometimes the walls of the arroyas, and rise in low monoclinal hills at various points on the plateau. The beds dip northeast 20° to 40°. In the intervals between the hills, there is a deposit of indurated clay of 40 feet in thickness, of Pleistocene age. I obtained teeth and other bones of Elephas primigenius, subspecies *columbi*, from this bed, and found bones of elephants in place in the banks of the arroya. Shells of Planorbis, Physa etc. indicate the lacustrine character of the deposit which I have called the Placita Marl."[12]

Deposits of the Jemez Valley.—The Pleistocene rocks of the Jemez valley are interstratified sands and clays. A section in the government well at Jemez showed the following:

Adobe clay at the surface	9 ft.
Cross bedded sand	4 ft.
Adobe clay, an old forest ground	6 ft.
Whitish yellow clay filled with freshwater gasteropod shells that look as though they were the same as species now living	6 in.
Cross-beded, loose sand	1 ft.
Conglomerate in which the prevailing cobble stones are black vesicular basalt	2 ft.
Red brown sand stone (Tertiary)	1 ft.

The above section was taken at the eastern margin of the deposit. The strata are much thicker in the central part of the area.

Another section was obtained from the government well made for the Zia Indians on the Zia reservation. There the adobe clay at the surface was found to be 16 feet thick and the underlying loose sand to be much thicker. The well did not penetrate the entire thickness of the latter.

These Jemez valley deposits cover a large area. They extend along the Jemez river from Cañon de los Jemez to the Bernalillo volcanoes a distance of 25 miles or more. Their average width is from 1 to 5 miles. This does not include the deposits along the lower Vallecieto creek, and lower Salt river, which in each case are very extensive. In these deposits at a considerable distance below the surface and far from the present river channel, wood is found, well preserved, though not petrified. These deposits by comparing them with those

at Placita, which Cope has identified as Pleistocene, are found to be Pleistocene in age.

Under what conditions these deposits were laid down need not be conjectured; the proof is at hand. After the river had cut its channel deep into the Tertiary from Cañon de los Jemez to the then wide valley of the Rio Grande, the Bernalillo volcanoes became active, and the lava flow filled up the channel in its lower course. This channel occupied the same site as the present one; but was much larger as is seen by the lava walls in the old trough on each side of the present river. Contemporaneous with this eruption, there was a shifting of the strata beneath the river bed as is very noticeable in the vicinity of the above volcanoes. A lake of considerable size was formed in which the beach sands were laid down, which today make that region a desert waste. This lake continued to exist till the lava dam at the east was cut out, and an outlet into the Rio Grande again established. Since then the re-adjusting of the strata has greatly elevated the deposits on the north.

The Rio Grande Marls.—The Rio Grande marls extend up and down the river for many miles both above and below Albuquerque. At the village of San Felipe the inner valley is wedged in; and for a short distance these deposits cease, only to appear again at Thornton and on the north. They are cross-bedded, permiscuously deposited, loose sands and gravels interstratified with bands of clay, the whole of which is overlain with an adobe deposit. The thickness reaches some 20 feet or more at a point just west of Albuquerque where excavations have been made to recover the supposed buried treasures of the Spanish people. Beneath the Rio Grande Marls were found the conglomerate beds which underlie the Jemez and Placita deposits. This seems to indicate that these marls belong to the same age.

The Age of the Rio Grande Deposits.—In the marls about Albuquerque undecayed wood has been found many feet beneath the surface; and in the same deposits at Paña Blanco were found the teeth and bones of the Elephas primigenius and other Pleistocene animals which strongly suggest that these deposits are of Pleistocene age. But even if no animal remains had been found, their age could still be determined. They are not only identical with the Placita deposits in most respects but are

a continuation of them. They can be traced from one to the other without break. The Placita formation being Pleistocene, these marls are Pleistocene also. Under what conditions the Rio Grande marls could have been deposited can only be conjectured by the writer, because his observations did not extend far south. It seems probable that at the time the Rio Grande series of volcanoes were active, there must have been not only a change in the position of the strata at different places along the Rio Grande embayment and in the bed of the channel itself, but the groups of volcanoes of this series must have poured a part of their lavas into the river channel and dammed the stream at various places. The first of these happened at San Felipe. A spur of the San Dias, forming a ridge in a curved line to that village, dammed the channel and caused a lake to be formed above the Indian village. The lake continued to exist until the river cut the channel where it now runs. The present channel at San Felipe must be younger than the lava flow inasmuch as it is incised in the latter; moreover had the original course of the Rio Grande occupied this area and it had been subsequently flooded with lava, we ought to find some evidence of the filling of the pre-historic valley but no data favoring this interpretation were obtained. In the vicinity of Ysleta however there is some evidence to prove that the prehistoric valley of the Rio Grande was completely dammed by the lava flows. More data bearing on this point, however, are necessary before such a conclusion should be fully accepted.

Resumé of the Stratigraphy of the Region.

At the close of Carboniferous time, or earlier the Jemez mountains were uplifted, and associated with their development are to be found large intrusions of granite and porphyry occupying an axial position. During the period of mountain building, the western flank of the Jemez was faulted off. These mountains were subsequently surrounded by a shallow Jurassic sea in which were deposited red sandstones and shales with gypsum, to a thickness of 2600 feet or more. Then came the Jurassic revolution. The mountains were re-elevated and the Jurassic strata to the west of the mountains were faulted and tilted to a nearly vertical position. At this time the volcanoes near Pelado and in the Valle Grande country became act-

ive and poured out the great rhyolitic sheet which now, on the plateau, covers the granite porphyritic core of the Jemez range, over which these same volcanoes hurled out 120 feet of pumiceous tuff. These mountains were still islands in Cretaceous times, but their area then was much greater than formerly. In this period the mountains seem to have been gradually rising until in the Fort Union epoch great swamps covered the entire country, the sea being obliterated for a time. In the swamps vegetation was luxuriant; and the vegetable matter laid down in them forms today the coal fields of northwestern New Mexico. At the close of the Fort Union epoch there was a slow subsidence. The Puerco was deposited on the Fort Union, followed by Eocene, the whole series being conformable. Then there came a violent change. The whole country was elevated above the sea; much faulted and broken up; and blocked basins on a grand scale resulted. The depressions were the lakes of Pliocene times. One large lake existed in the vicinity of Jemez, another, in the Rio Grande valley. The lake at Jemez was filled up with the Jemez marls by the tributaries of the Jemez river, and the Rio Grande lake was silted up with the Albuquerque marls, probably by the tributaries of the river which at present occupies that valley. When these lakes were nearly filled, there was a further re-elevation of the country and the rivers at once began to incise channels for themselves; but this deepening of their channels was suddenly arrested by seismic disturbances and the lava flows of Post-Tertiary times. The former changed the incline of the river channels, and the latter damned the rivers, thus forming lakes. In these lakes were deposited the Pleistocene depostis of the river valleys, the Placita marl, the alluvium, etc. At the close of the Pleistocene, these lakes in turn were obliterated and the country took on the general appearance that it has today.

Geography and Physiography.

Rivers.—The rivers of the section are: the Rio Grande, the Rio Puerco, and the Jemez.

The Rio Grande.—The Rio Grande river flows to the east of the Jemez mountains and to the west of the San Dia escarpment. It is west of Albuquerque and east of San Felipe. It is a stream an eighth of a mile in width at San Felipe; at high water it is often a half a mile or more in width at the village.

Below Albuquerque, except during high water, the water seeps into the sand and the river bed becomes dry. The river at this point runs through a wide inner valley or flood plain on the down throw side of the San Dia fault. Here the river indicates at least three states of activity. In the early Post-Tertiary it cut out a deep, wide channel in the Pliocene rocks. Then it refilled the trough, thus formed, with the Rio Grande marls discussed above. Now it is again deepening its channel.

Age of the Rio Grande.—The Rio Grande at Albuquerque is younger than the Pliocene in which it cut its deepest channel. But where its channel at San Felipe was during the early Pleistocene is unknown. It was not where it is now, because the Post-Tertiary lava flows covered the area through which the present channel is cut. Had there been a channel at this point we should expect to find portions of the lava in its original position, within its boundaries but no evidence of this sort was obtained. It is quite possible that the river in early Post-Tertiary flowed farther to the east where the Pleistocene deposits are now to be found near Placita and that anticlinal uplift which sends a spur north from the San Dias to the east of Placita changed the course of the river to its present location.

The Rio Puerco.—The Rio Puerco closes in, on the west, the lands described in this paper. It is a tributary of the Rio Grande, entering that river below Albuquerque. It runs at such an angle to the Rio Grande that the lands between them form a V-shaped area. Its source is in the Puerco beds at Nacimiento west of the Jemez mountains. The Puerco's general course is south. It has no tributaries except near its source. In its lower course, it has cut for itself a canyon some 800 feet in depth. This stream is dry nearly all the year round.

The Jemez River.—The Jemez river like the Rio Puerco, is a tributary of the Rio Grande. Its direction of flow is southeast. Near San Isidro it branches, and Salt river passes around to the west of the Nacimiento mountains. Farther north it again divides, one branch goes east of the Red Beds in the Vallecieto valley, another west of these beds through Guadelupe Cañon, and the third or middle branch up San Diego Cañon, which is chiselled in the Red Beds along a fault line. These trubutaries divide and subdivide till their branches pene-

trate every part of the plateau. This river, with the exception of its western branch, drains the inner arch of the Jemez mountains, the space between the Nacimiento mountains on the west and the Cochiti range on the east. The tributaries of the Jemez are mountain streams and usually have running water in them; but, in the lower course of the river, the water seeps into the sand and the channel is almost always dry. Its western branch, Salt river, drains the Fort Union formation, and the Puerco beds to the west of the Nacimiento mountains. It occupies a wide flat-floored valley with canyon-like slopes. In its lower course it flows along the down throw side of Mesa Blanco. The tributaries of the Jemez on the north occupy deep narrow canyons. Their source is in the rhyolitic flows 8000-11000 feet above sea level; each has cut its channel through the volcanic debris into the Upper Carboniferous; and each in its lower course has chiseled the whole or a part of its channel from 1300-1600 feet in depth in the Red Beds. The Jemez Tributaries are noted for their medicinal springs.

Age of the Jemez River.—The probable life history of the Jemez river is most conveniently presented under the following subdivisions of its drainage area: First, the Jemez and its tributaries to the north of the Indian village of Jemez; second, its western branch, Salt river; third, the Jemez river below Canyon de los Jemez.

The Tributaries of the Jemez River at the North.—The tributaries of this river to the north of the Indian village of Jemez all have their sources in the high rhyolilic plateau of of Jemez mountains. On leaving this plateau each has cut a deep but narrow canyon. The upper part of each of these canyons is in Carboniferous rock; its lower part in the Red Beds, each canyon in its lower course often being more than 1200 feet in depth. At canyon de los Jemez, Guadalupe and San Diego creeks which have gathered in all the upper tributaries, except Vallecieto creek, unite and form the Jemez proper. At this point the united river enters the site of a Tertiary lake, probably at an earlier date a Cretaceous lake which was silted up by the rivers of the upper country. There is no evidence that these streams occupied their present site in Jurassic-Cretaceous times; but, as there is no evidence to the contrary, and as deposits of Jurassic-Cretaceous age were laid down in

the area to the south of the Red Beds, it is quite possible that they did then exist, because the dip of the Carboniferous, and Red Bed strata have remained unchanged so far as direction of dip is concerned since the Red Bed revolution; and the Jemez plateau has furnished a water supply for streams since even earlier times. The origin of these streams must, therefore, date back at least as far as the early Jurassic-Cretaceous or even earlier.

Salt River.—This river has its source in the Puerco marls west of the Nacimiento mountains. Its channel is cut partly in the Fox Hills and partly in the Fort Union rocks. Near its confluence with the Jemez it follows the course of the fault north of the Mesa Blanco. Its age must antedate both Pleistocene and Pliocene times inasmuch as both series are found resting upon its valley floor.

The Lower Jemez River.—In Pliocene times the upper tributaries of the Jemez together with the Salt river silted up the Jemez lake. The lake being filled, the various streams united and cut a channel to the southeast to the Rio Grande embayment, which channel is here called the lower Jemez river or the river below Cañon de los Jemez. The age of this part of the river, therefore, dates from the earlier Post-Tertiary times. As the country was being rapidly elevated in Post-Tertiary times the river cut a deep, wide channel in the partly lithified Tertiary sands and clays. But its activity was suddenly arrested at the time of the Post-Tertiary volcanic disturbances Its channel was filled with lava near its confluence with the Rio Grande by the Bernalillo volcanoes as the remains of that lava-flow, in the old valley, show. At the time of this lava flow and immediately following it, the river bed in its lower course was elevated. A Pleistocene lake was thus formed; and in it about 100 feet of loose sands, gravels and clays were laid down. The lake remained in existence till an outlet was made through the lava barrier. The site of the lake then became dry, and has remained so to the present time. Since then the readjusting of the strata has elevated the old lake bottom on the north, thus causing the river to cut its channel deep in the loose Pleistocene. The stream in its lower course still has a considerable fall; but, owing to the fact that its waters seep into the sand before reaching the Rio Grande, its flood plain is being built

up at present by the sediment carried down by its tributaries.

Mountains.—The mountains of this section are the San Dia and the Jemez.

The San Dia Mountains.—The San Dia mountains were caused by a drop of 11,000 feet along their western side, leaving an escarpment of 7,000 feet still remaining (Cope). The origin of these mountains dates back to a period later than the close of the Carboniferous usage, because their crest everywhere is Carboniferous rocks. These mountains are situated about 8 miles east of Albuquerque and 25 miles to the southeast of Bernalillo. The dip of their strata is from 12 to 20° to the southeast. These mountains close in the Rio Grande embayment on the east of Albuquerque.

The Jemez Mountains.—The Jemez mountains form a U-shaped plateau, the open space being toward the south in which most of the head streams of the Jemez river have their sources. The west portion of the U-shaped mountain area is called the Nacimiento mountains, and the east, the Cochite range. Its culminating point is Pelado whose crest is 11,200 feet in altitude. The core of these mountains is red feldspathic porphyry of the true Rocky mountain axis. The upper northwest part of these mountains terminates at the village of Nacimiento; and the southern limit of each member terminates at the south in the latitude of the Indian village of Jemez. They are situated 60 miles to the west and southwest of Santa Fe and 55 miles north of Albuquerque. These mountains, judging from the youngest strata which flank their sides date back at least to Pre-Jurassic time. The oldest strata exposed are Carboniferous. They have been re-elevated at different times, as will be seen in the sequel.

Villages and Cities.

The villages and cities of this region are:—The Indian villages of Santa Ana, Zia and Jemez, and the Mexican villages of San Y Sidro, Cañon de los Jemez, Perea (the Jemez Hot Springs) and the Sulphurs on the Jemez river; the Mexican villages of Cabizon, Lavantana and Nacimiento on the Rio Puerco; and the Indian villages of San Felipe, San Dia and Ysleta, the Mexican villages of Thornton, Algodones, Bernalillo and the city of Albuquerque, on the Rio Grande. Albuquerque is one of the leading cities of the southwest. Among

its buildings is the large stone depot of the Santa Fe Company. This building besides serving as a depot, contains the Harvey Eating House and hotel, a natural museum exhibited by the Santa Fe as an advertisement of the mountain country. It also contains a library of considerable size. This city, with its mixed population of Mexicans, Americans, Germans, English, French and other nationalities, is the chief business center of the southwest.

General Survey.

On the whole the section of country under consideration in this paper, is one vast desert area sparcely covered with grass, piñons, red cedar, sage brush and cactus, except in the valleys where there is sufficient water for the purposes of irrigation. In these valleys, corn, wheat, fruit and beans are raised by the natives and Mexicans. To consider the entire area again, it presents two basin-shaped districts, the Rio Puerco and the Rio Grande basins, with the strata in each respective basin dipping toward the center. The separating line between the basins is the Nacimiento mountains, the west wing of the Jemez mountains. It is continued southward in a line of hills which decrease in altitude as they recede from the main range. The two basins merge into one below Albuquerque.

The whole area is faulted and much broken. High escarpments frequently remain to mark the fault lines. Examples of such escarpments are: the San Dia mountains, Mesa Blanco south of Salt river, and one on each side of the Red Beds just south of the Jemez range. There is also evidence that the Nacimiento mountains were originally, the result of a drop on their western side. The resulting escarpment has been worn down and subsequently covered in part so that it is not so strong in relief as the San Dia escarpment; the Carboniferous strata which flank this range on the east is entirely wanting to the west of this range. Mesa Blanco was left an escarpment by a drop on its northern side of more than 1600 feet, 1000 feet of which still remain. The escarpment to the east of the Red Bed mesa above mentioned is now 900 feet in hight and the escarpment to the west of the same mesa is 1700 feet. The strata of this mesa dip toward the east at a great angle on its western margin, and at a greater angle toward the west on its eastern side. The whole country, as is indicated above, is ex-

tremely broken up; and in its canyons are to be found numerous springs, celebrated for their medicinal properties. Its hills are few; but its hogbacks parallel ridges, weathered cones and castled buttes are many; and its fault lines and escarpments are numerous. The valley floors are covered with shifting sands, and along the lower course of the Jemez sand dunes are piled up by the ever blowing wind. Much of the upper country is covered with tufa, and many of the lower mesas have a cap of basalt often of the "Malpais" type. The culminating points of the Jemez-Albuquerque region are: the crest of the San Dias, the monolith Mt. Cabizon on the Rio Puerco, and Mt. Pelado, the culminating point of the Jemez mountains.

The rivers and mountains having been discussed under geography and physiography, they will receive no further mention here; but the remaining physiographical features of the section will be treated at some length.

Sand Dunes.—The sand dunes are in the lower Jemez valley. They are the result of the piling of the shifting sands of that valley by the winds; as has been stated, this valley was a lake in Pleistocene times, and the shifting sands of today were the beach sands of that lake. As evidence that this conclusion is true: first, the sands are all rounded and water-worn, and second, in the eastern part of the lake where the clay sediment brought down by the streams to the west and north of the then lake did not extend, the sands are deepest, because here the chopping waters reduced the surrounding partly lithified Tertiary sandstone lake-wall to sand; besides, the drift of the sandy particles deposited in this lake to the northwest would naturally drift toward the southeastern beach. This sand, as we have seen, is of Post-Tertiary origin.

Mt. Cabizon.—Mt. Cabizon is a volcanic neck of great size. It is situated just across the Rio Puerco from the village of Cabizon (La Poste). Its crest is more than thirteen acres in area and its hight above the plain in which it is situated exceeds 1400 feet. It is, therefore, a land mark throughout the entire region to the west of the Nacimiento mountains, and even further east to the Rio Grande area below those mountains. Its age is Post-Cretaceous, though it probably continued in action till the Tertiary was far advanced. A further mention of this volcanic neck will be given later under volcanoes and lava flows.

Pelado.—Mt. Pelado or "Balda," as it is commonly called, is the culminating point of the Jemez plateau. The altitude of its crest is 11,200 feet. It is a solid mass of porphyry. It is situated just to the west of the great Valle Grande tufa volcanic region and seems to have once been the west front of the largest crater. The greater part of the rim still remains. The site of the crater today is in a level area to the east of that mountain.

Medicinal Springs.—Along lower Salt river and in the upper Jemez river region there are many springs, some hot, some cold, and others of a bathing temperature. The waters of all these springs possess medicinal properties; and the principal springs have been health resorts before the invasion of the white man. These springs seem to be in groups. The principal groups are: the Sulphurs, the Springs of the Soda Dam in the Jemez river, the Jemez Hot Springs at Perea, the Indian Springs, the San Ysidro Springs, and the Philip's Springs. The latter three groups of springs are cold or just bathing temperature; the remaining groups are hot, the Sulphurs reaching near the boiling point. These springs will be considered in reverse order.

The Philip's Springs.—The Philip's springs are forty in number. They are situated in a little cove between the granite spur to the southwest of the Nacimiento range and the Red Beds to the west of Jemez on their western side. The space occupied by them is not greater than thirty acres, though at an earlier date their area was much more extensive than now, as is attested by the tavertine cones left by the extinct springs. The cove, occupied by these springs, is about a mile to the northeast of Salt river; and eight miles nearly west of Jemez Pueblo. The springs of this group are soda or iron springs. The soda springs deposit a cone of tavertine around their mouths, the iron springs are non-depositing. The springs of this group usually have a bathing temperature; but they are not used for bathing purposes on account of their isolation, though their site would make an excellent place for a health resort. The scenery is as good as could be desired; and what adds more to their value, is that they are so situated in this cove that they are sheltered from the sand storms so prevalent in New Mexico. These springs, however, have one drawback

to their becoming of value in the near future: they are situated on the Ojo del Espiritu Santo land grant; and a title to the area cannot now be obtained.

The San Ysidro Springs.—The San Ysidro (San Isidro) springs are situated on either side of Salt river in its lower course all along the front of Mesa Blanco, their waters coming to the surface along the fault. These springs are some forty in number. Those to the south of the river are bitter magnesium, and those to the north, are soda springs. The waters of the springs are cold. They have medical qualities; and throughout the summer months, the Mexicans bathe in them. These springs are on government land, but, as all salt lands in New Mexico have been reserved for the benefit of the university of that territory, they will most likely be claimed by that institution on account of the magnesium and sodium salts.

The Analysis of the waters is as follows:[13]

Specific gravity	1.0023
The mineral matter in 100 parts of water:	
Carbonate of sodium	0.3072
Sulphate of soda	0.1639
Carbonate of lime	0.0670
Carbonate of magnesia	0.0243
Carbonate of iron	0.0008
Potassa, Lithia, Silicic acid	traces
	0.5632

The Indian Springs.—The springs here designated as Indian springs are a heterogeneous group, and extend in an east and west direction in a narrow belt of land about a mile to the north of the Mexican village of San Isidro. At the west their waters are forced to the surface along the fault to the north of the little gypsum area just north of Salt river. It is also highly probable that this fault extends as far east as the springs do, though in that part it is covered with later deposits. The springs are alkaline, but not depositing springs. They are cold in the west but increase in temperature toward the east end of the belt. The temperature of the eastern springs, those to the east of the Jemez river, is about 120° F. They are being covered continually with debris brought down by an eastern arroya and must be dug out when used. The Indians use these springs

almost continually throughout the summer months; even the Ysleta Indians come there to bathe for their ailments. These sources of health and cleanliness are on Indian lands, whence the name. Should they be properly cared for there is reason to believe that they would afford a health resort of the first class.

The Jemez Hot Springs.—The Jemez hot springs or "Ojos Calientes," as the Mexicans call them, are situated in the Jemez river bed in Cañon San Diego at Perea. The site is a beautifully picturesque one. The Red Bed walls of the cañon rise 1200 feet on either side of the river, while in the valley a little north of the springs is the ruins of the Indian village of San Juan de los Jemez and the Spanish Catholic church and fortification of the first occupation of the Spaniards.

These springs are located geographically in two groups. The lower group is owned by a man by the name of Judt, and the upper one by the Otèros. Each firm has erected comfortable bathing houses and sweating rooms. Hotels have also been erected for the benefit of the health seekers. A stage also runs between these springs and Albuquerque.

The temperature in Judt's group of springs is 119° F. The specific gravity is 1.0016, and the chemical analysis shows the following:

In 100 parts of water there are:—

Chloride of sodium	0.1508
Sulphate of lime	0.0262
Carbonate of lime	0.0300
Carbonate of magnesiam	0.0240
Carbonate of iron	0.0002
Silicic acid	0.0010
Potassa, Lithia, Carbonate of lime	trace
	0.2332

The temperature of the Otero group of springs is 168° F. and the chemical analysis shows the following:

In 100 parts of water there are:

Carbonate of sodium	0.1622
Sulphate of soda	0.0035
Carbonate of lime	0.0641
Carbonate of magnesia	0.0103

Lithia Silicic acid Sulphate of lime Potassa	}	trace
		0.2401

These springs are known throughout America and Europe; and it is not infrequent that one meets a foreigner here.

The Soda Dam.—The Soda Dam is a long tavertine ridge built directly across the Jemez river at a point two miles above the Jemez Hot Springs. The ridge of tavertine has completely dammed the river. On it are situated 22 springs, or about one-half of the springs of this group. They all deposit tavertine and their charged waters running over the dam causes the cap of the dam to be built out farther and farther to the south each year, thus leaving rooms beneath the cap. These rooms are decorated with stalactites suspended from the roof. They are exceedingly picturesque.

The waters of the springs come to the surface after encountering a granite wall in their southern course, which crosses the country in an east and west direction; hence the line of springs.

These springs existed in former geologic time and then dammed the river with their deposits the same as today. The remains of the first dam is nearly 1000 feet above the present one; and, as the river has cut its channel down, a succession of dams in step-like order has been formed. These dams, therefore, are evidence that Canyon San Diego was not formed altogether by a faulting of the strata; but that the Jemez river has here chiseled out for itself the present channel. They also indicate that the Jemez plateau has been raised by a series of uplifts, each dam marking a period of rest.

The temperature of the gushing waters of these springs is from 75° to 105° F., the specific gravity is 1.0023; and the chemical analysis shows the following minerals in 100 parts of water:[13]

Chloride of sodium	0.2642
Sulphate of soda	0.0059
Carbonate of soda	0.0219
Carbonate of lime	0.0548
Carbonate of magnesia	0.0057

Silicic acid	0.0201
Phosphoric acid, Potassa, Lithia	trace
	0.3726

These springs are not used for bathing purposes. The reason is that the more health-giving Jemez Hot Springs are too near.

The Sulphurs.—To the north of Pelado about twenty-five miles to the northeast of the Soda Dam and the Jemez hot springs (Ojos Calientes) on the very top of the Jemez Plateau are the famous sulphur springs and still further to the northeast are the San Antonio springs. The latter attain a temperature about the same as that of the Indian springs to the east of the Jemez river. The Sulphur springs deposit sulphur in considerable quantity as the name indicates; and their site was obtained as a mineral claim. They are owned by the Oteros, and their value is now estimated at $100,000.00. Bath houses and accommodations for health seekers have been erected. A stage runs from Thornton on the Santa Fe from the east to this place, and one also reaches it from the south via Albuquerque.

The temperature of the waters of these springs is close to the boiling point.*

General Survey of the Springs of this Region.—As we have seen, most of the springs in the Salt river and upper Jemez country are along faults or granite dikes where the under ground waters are checked in their downward course and forced to the surface; but as yet we are unable to see why some of the groups of springs are hot; others a bathing temperature; and still others cold. Let us examine the facts and see if we can obtain a solution.

The springs on the top of the plateau to the north of Pelado approach boiling point, while the Jemez hot springs, about the same distance to the southwest of that mountain, are 168°F. The San Antonio springs twelve miles to the northeast of the Sulphurs are only a bathing temperature, as are also the Philip's springs south of the Jemez mountains, and eigh-

* The writer never visited this group of springs, but obtained his information from a gentleman who once had charge of them.

teen miles to the southwest of the Jemez hot springs; and the San Isidro springs farther south are mostly cold. What causes the temperature to decrease on either side of Pelado as the distance from that mountain increases? The solution seems to be this: As has already been stated, Pelado was once the centre of a volcanic area, as the remains of the tufa flows and crater walls attest. Long since these craters ceased to be active; but their reservoirs are still hot. The percolating waters then on coming in contact with the heated rocks come to the surface as hot or warm springs, thus perpetuating volcanic activity in the secondary stage. The farther the springs are from this volcanic area the cooler they become till at San Ysidro they are cold.

The Tufa Flows.—A tufa flow covers the Jemez plateau as far as visited. It also extends south over the Red Beds as far as Canyon de los Jemez. The tufa deposit on the Red Bed triangle between Canyons Guadalupe and San Diego is from one hundred to two hundred feet in thickness. It was hurled out of the volcanoes at the foot of Pelado and in the Valle Grande country. Some of these volcanoes, as we have seen, are of great size and the leveling and filling of their craters has made the Great Valley (Valle Grande) country.

Age of the Tufa of the Jemez Mountains.—In speaking of the age of the tufas of this region, Prof. William Jenks in the New Mexico Mining Record says:

"In the Jemez range of mountains of which the Cochiti range is relatively a part, the pumiceous tuff was erupted during or at the close of the Jura-trias (Red Bed) period. We find there in a clear order, a base or central axis of red granite (red feldspathic porphyry) Carboniferous limestone, Permian and Jura-trias red and white sandstones and variegated shales, with superincumbent pumiceous tuff."

Prof. Jenks in the *Sunbeam*, of Bland, New Mexico, Nov. 1st, 1899, writes again concerning the age of these tufa flows and says:

"I cannot imagine that this tufa flow so far as the Jemez and Cochiti mountains are concerned was later than pre-Cretaceous; for, as the higher portions of these mountains had been occupied by the Cretaceous formations, some small remnant of it would be found somewhere within the area. For myself,

I have never seen the slightest trace of anything later than Jura-Trias." (Red Bed series); "and tufa covers these beds, but never covers, so far as I know, the Cretaceous or Tertiary formations on the edge of the ranges."*

Dr. C. L. Herrick, then president of the University of New Mexico, took issue with Prof. Jenks, believing that the tufa was of Cretaceous age; and asked the writer by letter to investigate the age of the tufa, which he did with the following results:

Tufa was found covering both the Carboniferous rocks and Red Beds, and also the granite plateau and the metamorphic rocks on the mountain flanks where the Carboniferous and Red Beds are wanting; but no tufa, in situ, was found on rocks of an age younger than that of the Red Beds. The investigation favors Prof. Jenks' opinion. The tufa therefore, seems to be at least pre-Cretaceous.†

The Basaltic Volcanoes.—The basaltic volcanoes and their lava flows are arranged in two series, the Rio Puerco, and the Rio Grande. They will receive consideration in the order given.

The Rio Puerco Series.—The Rio Puerco series of basaltic volcanoes begins at Cabizon with Mt. Cabizon as the northeast crater and continues on in a southwestern direction. The plugs of the craters now dot the country, Mt. Cabizon being the largest one, thus indicating, in a way, the amount of erosion that has taken place since these craters ceased to be active. The lava, for the most part, has been almost wholly removed. A careful examination reveals the fact that the volcanic rocks protrude through Cretaceous strata, and moreover that no lava of these eruptions are in situ on Tertiary deposits, though co marls. The conclusion drawn from the observations is that they rest in places on the Fort Union and possibly on the Puerthese volcanoes are post-Cretaceous in age.

The Rio Grande Series of Basaltic Volcanoes.—The Rio Grande series of basaltic volcanoes has a general northerly and southerly course. Their direction is the result of a seismic disturbance, opening up a fissure that can be traced from a

* Prof. Jenks has prospected the entire Jemez range, and is to-day one of the leading stockholders in the Cochiti Gold Mining Company at Bland, New Mexico.

† There are several tufa patches near Albuquerque, all of which seem to be post-tertiary in age.

point south of Albuquerque north by the way of Cochiti beyond Abiquiu, in Rio Arriba county, a distance of 100 miles. On this dike there are several groups of volcanoes, some of which are: the Albuquerque, the Bernalillo, and the San Felipe volcanoes.

The Albuquerque Volcanoes.—Across the Rio Grande to the west of Albuquerque about six miles, six volcanic plugs arranged in a north and south direction project above the mesa. From these craters a lava flow seems to have spread out in all directions. It is black vesicular basalt, and covers an area of about thirty six square miles. Its thickness is about 20 feet. The lava rests on Eocene strata.

The Bernalillo Volcanoes.—The Bernalillo volcanoes are situated to the west of the Rio Grande at its confluence with the Jemez river four miles to the northwest of Bernalillo and twenty miles to the north of Albuquerque. Craters are found on each side of the Jemez; but the one to the south of the river is the most conspicuous. The loose Eocene strata have been removed from it and the plug of the volcano or "neck" now protrudes above the general level of the surrounding country. From the plug dikes radiate, giving a rib-like structure to the exposed surface. The lava flow to the south of the river Jemez has been removed for the most part; but to the north, the lava sheet is thick and continuous with the lavas poured out by the San Felipe volcanoes. The lava is black vesicular basalt the same as that of the Albuquerque volcanoes.

These volcanoes are of interest because their lavas pouring into the old channel of the Jemez river brought about a period of damming, thus forming the Pleistocene lake of the lower Jemez, previously mentioned under the head of "Pleistocene Deposits in the Jemez valley."

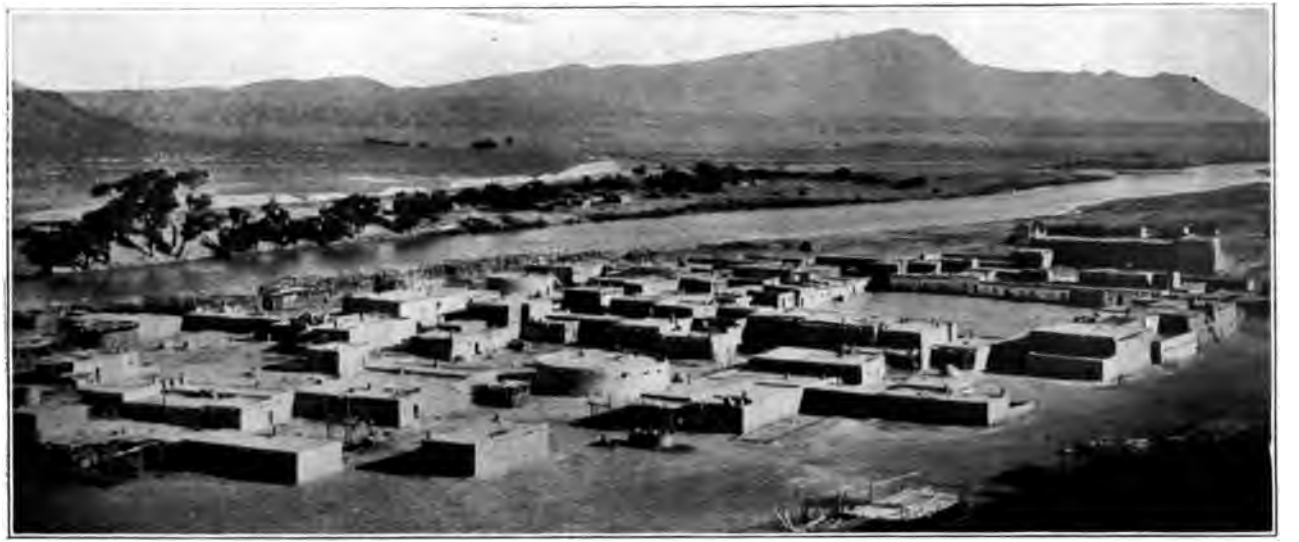
The San Felipe Volcanoes.—The San Felipe volcanoes are many in number. Thirteen were visited by the writer and Dr. G. B. Haggett in one day. Most of the pot-like craters are small; but some of them are of large size. One in particular that we measured was one-half mile in diameter and another was still larger. The walls of the half mile crater are still in existence. The walls within the depressions were found to be glazed and blackened and to be composed of sand mixed with fragments of basalt. The remains of most of the volcan-

oes are "plugs" or "necks"; but in a few cases both the outer wall and the inner plug still remain; and in the case of one of the larger craters, side craters, forming lateral vents, were seen.

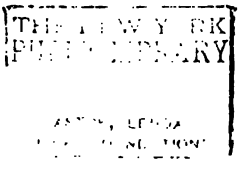
These craters are situated on the mesa to the west of the Rio Grande, near San Felipe, for which the writer named the group. The southernmost crater observed is about two miles to the southwest of the village. The craters of this group are in a line, curving to the west along the great dike. They rise in altitude, one above another as they appear farther to the northwest till they reach the summit of the mesa where the largest one of the group is to be seen. Its plug rises 6500 feet above the sea, and its diameter is more than a half mile in one direction and a mile and a quarter in another. To use the words of our Indian guide; "Esta padre de todas," it is the father of all. From it toward the west the craters become less and less in hight till they are reduced to the level of the mesa. The lava flow from these craters covers 300 square miles in solid mass, and many more miles in detached patches. The lava flow is augmented at the west by the flows from the Cochiti volcanoes and by the flows from Mt. Negro (Sierra Negro). It reaches the Pueblo of Jemez on its western limit and covers almost the entire space in the triangle between the Rio Grande and the Jemez river to the south of Canyon Honda. The lava sheet is from twenty to one hundred and twenty feet in thickness. It is of the basaltic type; and, on account of its broken down, rough condition, it is called "Malpais."

Date of Eruption.—The age of the lava flows is only conjectured. Dr. Herrick first supposed that the underlying strata which are red and grey sandstones, were of Cretaceous age, and so stated in his "Geology of the Environs of Albuquerque," New Mexico, (Bull. of the University of New Mexico, V. I, pp. 40-43). In this paper on the environs of Albuquerque he says:

"These bluffs (the bluffs that border the Rio Grande on the west) afford the most instructive illustration of base-leveling that could be imagined. The basalt reposes on the red and grey Cretaceous strata, which here remain nearly horizontal. The sources of these flows is not difficult to



San Filipe Pueblo. Mt. San Dia in the distance, Rio Grande in the centre. 600 Inhabitants.


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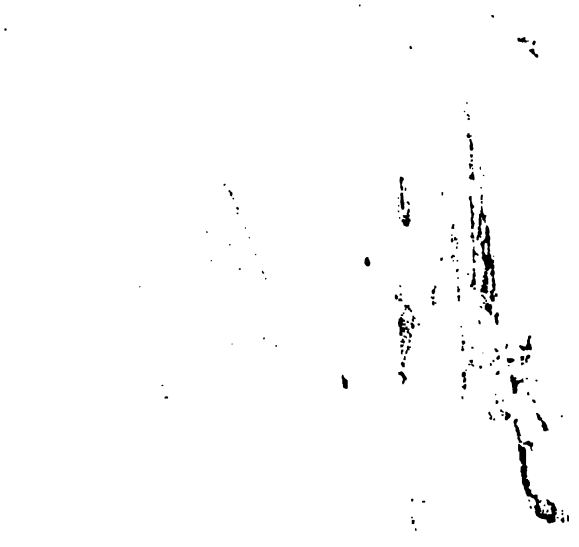


Jemez Pueblo, and mountains opposite. 1 is Granite, the core of the Nacimiento mountains; 2 is Upper Carboniferous; 3 is Red Beds; 4 is Pliocene; 5 is Pleistocene. The country rock in the centre of the picture is Permian.


NEW YORK



Bluffs at Jemez springs; white colored rock volcanic tuff; upper portion all tufa and basalt.

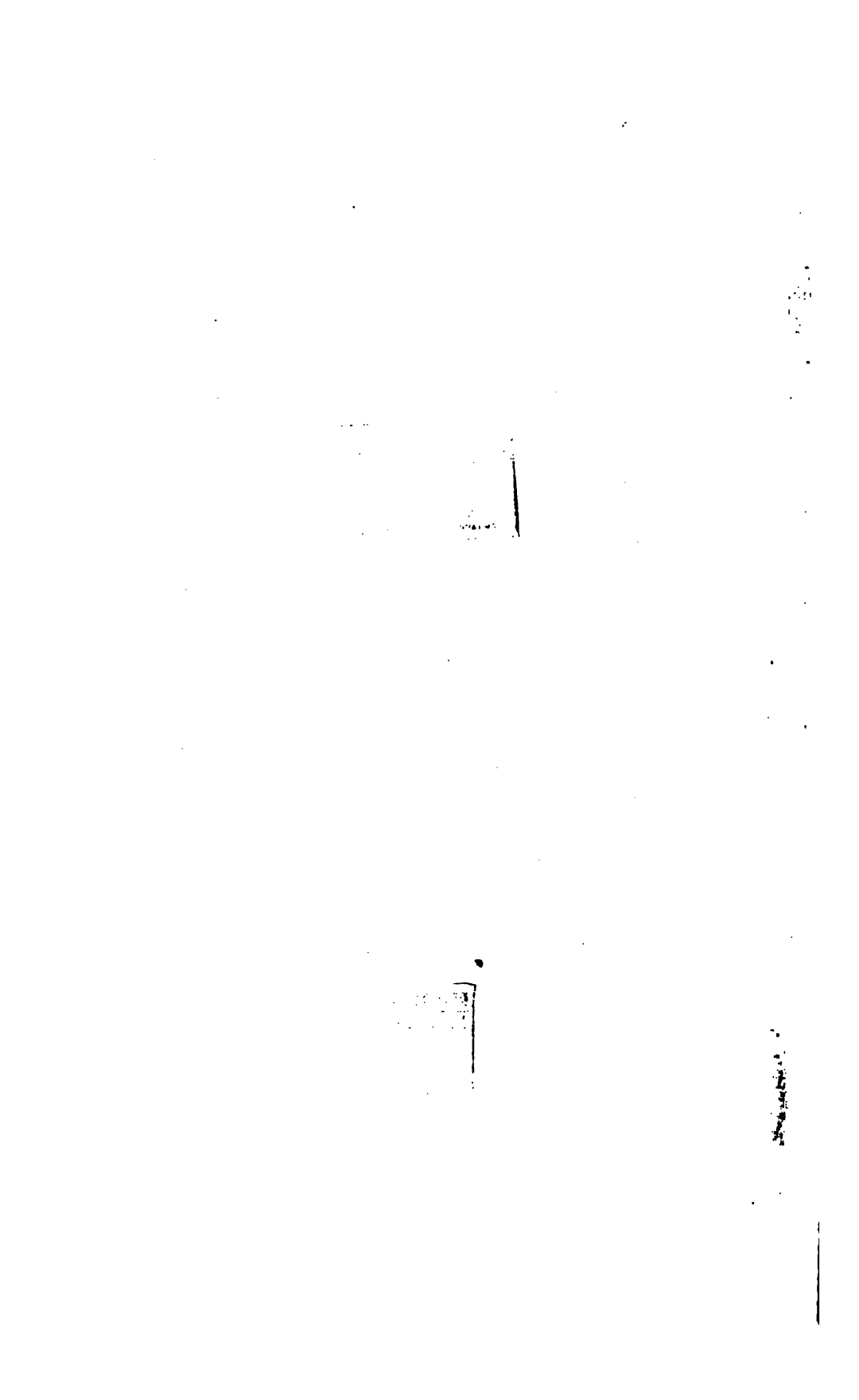




The largest volcano of the "San Filipe" group, showing its two plugs. This volcano was named San Filipe by the artist, Mr. G. B. Haggett. The foreground shows the typical "mal pais" country.



The Little Pygmy volcano, two and a half miles southwest from San Filipe.





locate in local craters which penetrate the Cretaceous at various places."

At another place he says:[1]

"Of course the age of these flows is still to be determined, though it may safely be placed at an earlier period than that in which the river gravels were deposited, that is, earlier than the post-glacial or Champlain period."

Again in speaking of the Albuquerque volcanoes, he says:[14]

"This group of cones is only one of a series of basaltic post-Tertiary volcanoes which can be traced along the entire length of the Rio Grande in New Mexico."

Herrick, in these articles, places the age of the volcanoes as post-Tertiary; but has them penetrating Cretaceous strata. At a later date he found that the strata along the Rio Grande embayment are Tertiary, and then he had the following printed on a slip in each of the bulletins:

The reader will kindly substitute the word 'Tertiary' for 'Cretaceous' wherever in the present article [The Environs of Albuquerque] reference is made to the sandy strata underlying the loess of the river valley."

The strata that these volcanoes and the great dike penetrate are Eocene as we have already noted. This formation overlies the Puerco and Fort Union, and of course, cannot be Cretaceous.

That these volcanoes are post-Tertiary there is no doubt, because the strata immediately underlying the lava cap east of San Felipe are Pliocene.* This lava also overlies the Jemez marls at Jemez. Another evidence that will aid in establishing the age of these flows is this:—while government farmer at Jemez, the writer dug a well for the Indian village; and, after digging through more than twenty feet of river filling of Pleistocene age, he found a conglomerate layer separating the valley deposits from the underlying Pliocene. In this conglomerate stratum were found boulders of black vesicular basalt, some of which would weigh 500 pounds. These boulders on examination, were exactly like the basalt in situ on the adjacent Pliocene mesa both in appearance and composition; and without question, were washed into the Jemez Pleistocene lake from the top of the very mesa. This, it seems to me, is evidence

* At this place there are two distinct lava flows separated by a forest ground with growth as thick as that now covering the region.

enough to establish the age of these lava flows in Post-Tertiary times, between the close of the Pliocene and the refilling of the Jemez trough with the Pleistocene deposits. Their age is late-Tertiary and early-Pleistocene.

Economics.

Climate.—The altitude of this region, 5000 to 9000 feet above the sea, and its latitude, 35 to 36 degrees north, combine to give it a climate which for mildness and equality has no superior in the world. Its location near the center of the vast rainless region of the west, and its remoteness from any large body of water, give it an atmosphere almost totally devoid of moisture. The annual precipitation is less than eight inches. At the same time, by reason of the latitude and altitude the air is both warm and light, thus furnishing, in unlimited quantities, nature's remedy for diseases of the lungs.

Soil.—The soil on the table lands especially on the Tertiary formations, is poor. There is too much alkali. But if water for irrigating purposes could be had, even the soil of these mesas, in a few years, could be made productive. It would require considerable labor and the use of fertilizers such as gypsum, burned lime, etc., but in the end it would yield profitable results.

On the mountain plateau the soil is good, especially in the Jemez mountains, in the Valle Grande country. This great valley occupies a high altitude, averaging 9000 feet. It embraces 100,000 acres and forms fine prairies with abundant grasses. On it also the fir and pine are most magnificently developed. This place is cool, and to it people go for an outing in summer. Here dews fall almost every night in the year.

Physical Conditions of the Soil:[15]

Fine and coarse sand	87.95
Fine silt and clay	12.05
Hydrascopic moisture	1.35
Chemical bound water and organic matter	3.63

Chemical Constituents of the Soil:

Potassa	.074
Soda	.011
Lime	.152
Magnesia	trace
Sulphuric acid	trace

Phosphoric acid	.029
Oxide of Iron / Aluminum	2.600
Insoluble particles of rhyolite	92.150

In the valleys the soil is, without exception, the best in the world. It surpasses even the soil of the Nile valley. An analysis of the Rio grande mud gives the following constituents:[15]

Potassa	1.784
Soda	.795
Lime	1.751
Carbonate of lime	5.190
Magnesia	.181
Oxide of Iron / Aluminia	14.890
Silicic acid	70.010
Sulphate of lime	trace
Phosphoric acid	.002
Water and trace of organic matter	5.012

Mr. Leow after giving the above analysis of the Rio Grande mud, remarks:

"Irrigation with these mud carrying waters furnishes the lands with a layer of the best virgin soil in a finely pulverized condition, and the belief of the farmer that the Rio Grande water is an efficacious fertilizing agent is fully warranted by the facts revealed by the chemical analysis. Indeed the inhabitant of the Rio Grande will never require any other fertilizer than the waters of the Rio Grande Del Notre."[15]

Irrigation.—All crops in this region and in fact throughout New Mexico depend upon irrigation for their growth. Without irrigation this region must be abandoned to the miners and stockmen.

There is no general system of irrigation along any of the water courses; but each village or community has its own respective ditch or ditches as the case may be; and in getting the water high enough to irrigate the desired lands in so short a distance, the rate of flow is reduced almost to the minimum. As a result a great part of the water is evaporated before it reaches the lands desired to be irrigated. Another drawback to the present system is that the water which is not used in the upper country is left in the streams; and on reaching the low lands, it seeps into the sand. A general system of irrigation on the Rio Grande was once undertaken. A large canal was

taken out of San Felipe which was to irrigate all the country within the valley east of the river to below Albuquerque; but, after work had been commenced, the ditch company became disorganized and the work ceased.

Larger and better crops could be raised if the water supply was properly handled.

Mining.—In the region described in this paper, there are no mines worthy of mentioning here; but just to the east of the Cochiti range are the Cochiti gold mines. Among the mines now in operation are the Washington, the Lone Star, the Albemarle and the Crown Point. The mill of the Albemarle mine alone puts out two bars of gold bullion every six days, valued at $3,600 each.

Mineral Resources.—Coal.—The Fort Union coal formation, as we have seen, underlies nearly all the lands in this region, except the mountain districts. Its coal outcrops are quite a distance from the railroad and until just recently only Mexicans and Indians knew of their occurrence. The coal is of good quality and the seams are thick. The time is not far distant when coal will be mined here on a large scale, the same as at Gallup at the western limit of the same coal horizon.

Gypsum.—As we have already noticed, the Jurassic rocks wherever found are capped with gypsum from 10 to 40 feet in thickness. Over 60 square miles of it are exposed in this region. Owing to its thickness and its lack of cover it can be worked to great advantage. With the growth of the railroad facilities a great industry will be developed, for the deposits are unusually pure and easily worked.

Gold, Silver, and Copper.—The mountains are crossed in all directions by mineral bearing veins; but, to date, the ores found are too low in grade to ship, the railroad being so far away; and the ore bodies are not sufficiently thick to warrant the erection of smelters on the ground. Should a railroad be extended up Jemez valley, however, mining there would at once become a paying business.

Placer.—Placer mining is carried on in the Placita marl district; but on account of the lack of water, only the dry-washer process for separating the gold is used. Men make good wages by this method; but if water for hydraulic mining

could be had, the placers of this region would be among the leading placers of the west.

This region with its building stone, with its gypsum for fertilizing, with its forests, with its medicinal springs, with its gold and silver veins and coal fields, and with its fertile soil and unequaled climate, is one of the best regions of New Mexico; and under proper handling will become one of the wealth producing regions of the country.

1. HERRICK, Bulletin of the University of New Mexico, Vol. I, pp. 38-43.

2. WILLIAM JENKS, in "New Mexico Mining Record."

3. "Bulletin of University of New Mexico," Vol. I, p. 103.

4. COPE, "U. S. Geographic Surveys west of the 100th Meridian." Vol. IV, pt. II, p. 3.

5. OSCAR LOEW, Coal from the Rio Puerco, near Nacimiento, New Mexico, p. 632, Vol. III, Geographic Surveys of the Territories.

6. DR. SMITH, "U. S. Geographic Surveys of the Territories." 9th annual report; Monograph Vol. III, p. 123. Also "Journal of Geology," Vol. VIII, pp. 448-449.

7. ENDLICH, "U. S. Geological and Geographic Surveys of the Territories, 9th annual report; Monograph Vol. III, p. 123.

8. COPE, Annual Report of Chief of Engineers, 1875, p. 89, appendix LL.

9. COPE, U. S. Geographic Surveys west of the 100th Meridian Vol. IV, pt. II, pp. 17-18.

10. HERRICK, Bull. Univ. of New Mexico, Vol. 1, plate XIII.

11. HERRICK, Bull. Univ. of New Mexico, Vol. 1, 1899, p. 30.

12. COPE, U. S. Geographic Surveys west of the 100th Meridian, Vol. IV, pt. II, pp. 24-25, and U. S. Geological Surveys west of the 100th Meridian, Vol. III, p. 163.

13. LOEW, Analysis of Mineral Springs, Vol. III. U. S. Geographic surveys of the Territories.

14. HERRICK, Bull. of Univ. of New Mexico, Vol. 1, p. 94.

15. LOEW, U. S. Geographical Surveys west of the 100th Meridian, Vol. III, pp. 578-582.

NOTE.—Should the Fort Union (Laramie) coal series of New Mexico and Colorado prove to be middle Cretaceous as many geologists contend it is, the formation called "Eocene" in this paper is Upper Cretaceous.

Dec. 17, 1902.

MORSE ON LIVING BRACHIOPODS.*

Reviewed by

CHARLES SCHUCHERT, Washington.

This very valuable and splendid work on some recent brachiopods is of so much value to students of fossils of this class as to be deemed worthy of lengthy review in this place. I shall limit myself at this time to such parts of Prof. Morse's work as have direct bearing on fossil forms. The observations recorded by the author were made more than twenty years ago and we had to wait this long time for this publication because of a minute study of Japanese pottery. In the meantime much of the author's work on *Lingula* and *Discinisca* was anticipated by Joubin and Blochmann.

Habits.—Paleontologists have long lamented that so little has been published on the habits of living brachiopods, and Morse remarks that it "is somewhat surprising when one considers the ease with which abundant material of certain species in life may be obtained. Without a study of the living animal, it is impossible to realize the activity of the lacunal circulation, the extreme mobility of various parts of the organism, the beautiful colors of the soft parts, and the varied and graceful attitudes of the brachia." (p. 316).

"Many of these animals may easily be kept alive; indeed, with the Ecardine forms [Morse uses this term for the Inarticulate, and Testicardines for the Articulate divisions] the vitality manifested by them is almost beyond belief. I brought home in mid-summer, from North Carolina, a distance of nearly seven hundred miles, living specimens of *Glottidia pyramidata*. These were kept in a small food bowl. They were afterwards carried to Eastport, Maine, and then to Troy, New York, yet none of them died until late in the fall, six months after. I also brought back from Japan a number of specimens of a small species of Lingula and not one of these died until late in the year. Joubin says 'the Crania remained exposed, upon my table, to the sun, cold, heat, without being injured. Numerous algae had invaded my basins. I had left

* Observations on Living Brachiopoda. *Mem. Boston Soc. Nat. Hist.*, V, July, 1902; pp. 313-386, plates 39-61. By EDWARD S. MORSE.

them entire months without changing their water which ought to have acquired a strong saltness. I have still the greater part of my Crania living seven months after their arrival in Roscoff and fourteen months after their gathering.' One cannot help associating this remarkable vitality in these genera with their persistence through geological horizons from the Cambrian to the present day almost unchanged in character. Living as they do in shallow seas, the gradual elevation or subsidence of the coast-line would in no way affect their condition. * * * * * They have survived all the mutations of geological times unchanged, and with the persistence of this vitality, they may be the last forms of life to survive on the earth as they were among the earliest preserved. On the other hand, the Testicardine brachiopods do not possess this vitality, and this group has shown an infinite diversity of form since its first appearance in geological time" (p. 316).

Glottidia pyramidata occurs abundantly at low tide buried in the sand of Bird Shoals, Beaufort Harbor, North Carolina. These small diaphonous Lingulae with long vermiform peduncles, when placed on sand would oscillate their valves from side to side and the fringes of setae would move in regular rhythm, causing the sand to gather in an irregular ridge encircling the animal or encasing only the posterior portion. Other specimens dug themselves out of sight by means of the peduncle in a vermiform way, or buried themselves head first by means of the anterior portion of the shell in a shoveling motion. "When at rest, the body would be half out of its burrow, the shells partially open and the lateral setae standing vertical and meeting at their tips." If alarmed, the shells are quickly jerked beneath the sand and out of sight. When the animal dies the shell "protrudes from its burrow and rests full length upon the sand" and the slightest jar of the vessel causes the body to float away from the buried peduncle. This seemingly explains why nearly all fossil *Lingula* are found flat on the planes of bedding. Two days after death to the body, the sand encased peduncle is as active as ever.

Lingula lepidula of Japan would dig themselves out of sight in from ten to fifteen minutes, and completed the making of their peduncle sand tubes in from twelve hours to three days. These tubes were in every case cemented to the bowl.

Discinisca stella of Nagasaki, Japan, "clung so closely to the rock, when first observed, that not until it erected itself on its peduncle did I become aware that it was a species of *Discinisca.* When I first dredged this species I mistook it for a species of *Crania*" (p. 323).

Individual Age.—Regarding the age of individual *Glottidia,* Morse thinks that they live but one year dying in the autumn, and the same seems to be true of *Lingula lepidula,* but L. *anatina* may perdure for two or more years.

Protegulum.—In *Lingula lepidula* "the [dorsal] protegulum is oblong-ovate, the posterior margin being straight; the periphery of this stage is distinctly yellowish in color, and this is of interest as marking a distinct period in the shell growth" (p. 322).

"In *Glottidia pyramidata,* the protegulum, while showing a straight posterior margin with a slight shoulder as it connects with the subsequent growth, is circular in outline. * * * In a species of Lingula collected in Nagasaki the protegulum is ovate with the same straight posterior margin. In all these instances, the peduncle is firmly adherent to the ventral shell, the beak of the dorsal shell standing free with an interspace between it and the peduncle."

"In *Discinisca lamellosa,* the [dorsal] protegulum is elongate-ovate with anterior and posterior margins equally rounded. A perfectly circular nucleus is outlined in the posterior half of this stage. * * * * It is an interesting fact that the successive stages of Discinisca begin with a nucleus eccentrically related to a perfectly circular stage; this circular stage, in turn, being eccentrically related to an oblong-ovate stage, which is the true protegulum; and this, in turn, being eccentrically related to an adult stage which is finally orbicular again."

The phylogenetic significance of Morse's remarks on the protegulum of *Discinisca* is not yet ascertainable, and this is particularly true in the light of the recent work on *Lingula* by Yatsu.* Until this year it has been thought that all brachiopods developed the first shell, or protegulum, on the inner side of the mantle before it is reflexed forward over the anterior

* On the development of Lingula anatina. By NAOHIDE YATSU. *Journal College of Science Imp. Univ. Tokyo, Japan,* xvii, pt. 2, art. 4, 1902, pp. 1-112, pls. 1-8.

lobe. In *Lingula* we now know that the neoembryo does not pass beyond the two lobed stage, and further that the posterior lobe is not the caudal lobe as in *Cistella, Lacazella* and *Terebratulina.* In *Lingula* the mantle is not reflexed and the protegulum is therefore from the beginning on the outer side of the animal. This discovery by Yatsu is seemingly of great taxonomic significance.

Coecal tubules and punctate shells.—Morse states that "a very marked characteristic of the Testicardine group is the presence, in the shell of many of them, of tubules with which the pallium has an organic connection. * * * * Precisely what their functions are is still problematical. * * * * It has been suggested that they might be respiratory" or "were instrumental in conveying growth elements to the shell." In the *Lingulidae* they may have "functioned as mucous tubes, but in these forms only the barest traces of their existence have been detected, and in no brachiopod have these pores been seen to open externally, at least in the adult form. It was long ago established that coecal prolongations of the pallium project into these tubular perforations of the shell. In all cases, at least in the adult, a delicate periosteum covers the shell, and consequently the tubules do not communicate with the exterior. * * * * That the coecal tubules are sensory organs of some sort seems highly probable." (pp. 324-325.)

The punctate nature of the shell in brachiopods is very common, and the very fact that these microscopic perforations are so abundant in certain families (terebratuloids and strophomenoids) and absent in many others, shows that whatever may have been their function, it was not an essential organ to all of them. On the other hand, these perforations are always best developed in the outer layers of the shell and may or may not be present on the inner layers. This condition of occurrence unmistakably indicates that coecal prolongations of the pallium where present, is a feature of youth, and is therefore most commonly seen in the outermost layer of the shell. Further, that in some forms the tubules functioned throughout life over the greater part of the shell, while in other, and apparently the great majority of cases, they are restricted as functional organs to the lateral and anterior margins. To make this point clearer I will give a number of cases which may be readily verified by others.

In recent *Terebratulina caputserpentis* or *T. septentrionalis*, the punctae may be seen on the inner and outer side of the shells. On the inner side, everywhere excepting about the teeth and their sockets, the rostral and muscular region. In no brachiopod have I seen punctae over the area of the muscular insertions.

In recent *Liothyris vitrea* the shell is very thin and is abundantly punctate on the inside as well as the outside except in the same regions as those mentioned for *Terebratulina*.

In thick shelled *Terebratula*, as *T. grandis* of the Coralline Crag, Suffolk, England, or in *T. harlani* of the Upper Cretaceous of New Jersey, the inner layer has no punctae throughout the thicker posterior parts of the valves. The thicker, or the older the shell, the more restricted are these punctae to the lateral and anterior margins.

In the strophomenoids, the regularly disposed punctae are well developed in the outer layer, but on the inside, very rarely if ever. However, in these forms, much of the anterior half of the inner sides of the valves are covered with more or less large pustules or even blunt spines. These may be regularly arranged in radial lines or irregularly scattered. Some of these, and especially the lower and smaller pustules, are plainly perforate. Apparently a single comparatively large coecal prolongation passed through these pustules and was branched toward the outer side in passing into the punctate outer layer. Undoubtedly in many cases these coeca became functionless and then the youngest or innermost shell layer over these pustules are not perforate. In nearly all strophomenoids the pustules are most abundant and perforate just inside the outer margin. The occurrences just described may be seen in the Lower Silurian *Rafinesquina alternata*, Upper Silurian *Leptaena rhomboidalis*, Devonian *Strophcodonta calvini*, *S. arcuata*, or Carboniferous *Chonetes granulifer* and *Productella pyxidata*.

These phenomena I find noted by Sharpe as long ago as 1847 (Quart. Jour. Geol. Soc. London, IV, p. 67, foot note). He states that "an inner layer of unpunctated shell lining an outer punctate layer is of common occurrence among the Brachiopoda." Sharpe observed this in *Orthis*, *Leptaena*, *Productus*, *Chonetes*, *Crania*, *Thecidea* and *Terebratula*. In

conclusion he states "Taking a general view of these punctated shells, it appears that in a very large majority of cases the punctations only remain open around the margins of the valves, so that it is probable that whatever function was served by these minute perforations, its operation was confined to the margin of the shell."

It is to be hoped that students of living brachiopods will find out what are the functions of these coecal prolongations of the pallium and whether the "delicate periosteum" covering the outer shell actually prevents the caeca from functioning except along the lateral and anterior margins.

Setae. "A very characteristic feature of the Brachiopoda is the setae which fringe the borders of the pallium. * * * In the errantian forms [these vermian hairs] are highly mobile and act, as in the annelids, as locomotive organs. * * * The setae were primarily locomoter in function and persist through inheritance, a secondary function being acquired in the *Lingulidae* in forming the lateral barriers to protect the palial cavity from the ingress of sand and mud. In other groups, a secondary acquisition has probably been established in furnishing a nidus for diatoms and other foreign growths which they sustain, often in rich abundance, for the benefit of the animal in furnishing, or attracting, a food supply. In all brachiopods, they undoubtedly act as a sensory apparatus for tactile impressions" (p. 328-9).

"In *T. septentrionalis*, the longitudinal ribbing of the shell corresponds to the number of setae; that is to say, at the marginal termination of every rib of the shell a seta projects; this is especially marked in the early stages of the animal" (p. 331).

Muscles.—It is evident from the work of Blochmann (Untersuchungen uber den bau der brachiopoden, Jena, published by Fischer, 1901) and Morse that our terminology of these structures needs emendation. For the inarticulates, Blochmann's terminology will probably come into use, but the application of these to articulate Paleozoic forms has not yet been attempted.

Pallium.—"The pallium [or mantle] is the principal respiratory organ. * * * * Nor can we consider the pallium apart from the shell, for both hard and soft parts of this

external covering belong literally to one and the same structure."

"In life, the pallium in the *Lingulidae* exhibits on its inner surface and around its borders a rich brown pigmentation. In the anterior portion of the pallium, this pigmentation assumes a definite color pattern. It is possible that these markings may offer characters for specific determination, though they would have to be made out from living specimens, as in alcohol these colors entirely disappear. The perfect symmetry of this pattern on each side of a median line, the rich brown color of the design in contrast to the pure white or greenish tinge of the remaining surface, with the rosy tints of the red circulating fluid in the lacunae, render the pallium a most beautiful object in life. * * * * The most conspicuous feature of the borders of the pallium are the crowded setae which spring from setigerous follicles somewhat deeply buried in the pallium."

"Viewing *Glottidia* from the dorsal surface, a treble, gourd-like outline is distinguished, which represents the boundaries of the coelomic wall. All markings within this outline are caused by the muscles, stomachal glands, genitalia, digestive tract, etc. All markings outside this outline are made by the brachia and the sinuses and lacunae of the pallium.

"The region enclosed by the dorsal and ventral pallium, fore and aft and laterally, communicates freely with the sea water. The treble, gourd-shaped figure may be defined as follows: the anterior portion embraces the region of the dorsal attachment of the lateralis muscles and the pharynx and oesophagus, and might be called the peri-oesophageal cavity; the second gourd embraces the stomach, a portion of the stomachal glands, and the first and second anterior occlusors, and may properly be designated as the perigastric cavity; the third and largest gourd, forming the main coelomic cavity, is nearly circular in shape and includes the intestine, a portion of the stomachal glands, the nephridia and genitalia, and the oblique and posterior occlusor muscles; this region may be called the perivisceral cavity" (pp. 349-351).

Pallial sinuses and blood circulation.—Because these sinuses are so often impressed both upon articulate and inarticulate brachiopods, it is deemed appropriate to quote Morse's description of them at length.

"The two broad pallial sinuses, so characteristic of all the *Lingulidae,* start from the perivisceral cavity at its junction with the perigastric cavity. * * * * The two main sinuses run to the anterior portion of the pallium, and, in Glottidia, make a graceful outward curve at the start and then a slight inward curve. The anterior terminations of these sinuses are only one-third the distance apart which separates them at their origin. On the inner side of these sinuses there start short lacunae reaching nearly to the median line and slightly inclined anteriorly. On the outer side of the sinuses there spring from nine to eleven lacunae having the same anterior inclination and reaching nearly to the base of the setae in the lateral margin of the pallium. * * * * The current passes outwardly along the inner side of the great pallial sinus, running into all the inner lacunae in turn, then reaching the anterior end of the sinus, it returns on the other side, running into each gill-bearing lacune in turn and coursing through each gill lappet. * * * * Another sinus turns directly backward from the opening of the main pallial sinus and follows along close to the lateral margin of the pallium sending a series of branching lacunae to the shallow posterior portions of the pallium. This I have indicated as the lateral pallial sinus. Beside the main pallial sinus and the lateral pallial, there is another which turns abruptly back from the main sinus opening, runs along on each side of the gourd-shaped outline of the perivisceral cavity, inclining slightly toward the median line, and disappears in a distinct round opening near the posterior lateral border of this outline. This I have designated the coelomic sinus. * * * * The pallium of *L. lepidula* shows marked differences from that of Glottidia in the disposition of the main pallial sinuses and of the smaller lacunae. In *L. lepidula,* the main sinuses run nearer the lateral margins of the pallium, and their terminations are wider apart than in Glottidia; furthermore the sinus has a uniform outward curve. The lacunae, which run off to the right and left with such regularity in Glottidia, are irregular and branched. * * * * The blood pours out of this opening (apparently the one to the perivisceral cavity) in a vigorous current on the inner side, runs along the inner side of the great pallial sinus, coursing through all the lacunae succes-

sively and then returns on the outer side, following up and down each lacune in turn. As the current approaches the main pallial opening, a part of the current is diverted to the outside of the lateral sinus, where it runs to the posterior end of the body to return on the inner side of the sinus, back to the main pallial opening into which it is directed. The sinuses, lacunae, and all details are symmetrically developed on each side of the median line. * * * * It is difficult to realize, unless one has seen it, the vigorous character of the flow of these currents. When the damming of the current takes place and a rapid accumulation of blood corpuscles piles up at the closed openings, the flood is impetuous when it starts again. The volume of this flow is so great that if any special organ was implicated in its propulsion it would easily be detected. No such organ, however, has been found. * * * * From the above observations on the circulation of the blood in the *Lingulidae,* it is certain that a propellent organ or heart is wanting in these animals" (pp. 351-355).

Students of fossil or living brachiopods cannot afford to be without this work of Prof. Morse, and no review will do it justice. In conclusion I will here present Beecher's summary of this work:—

"Morse's observations refer principally to the genera *Lingula, Glottidia, Discinisca, Hemithyris, Dallina, Terebratalia* and *Terebratulina.* The points of especial interest comprise the discussion of the otocysts, pharyngeal glands, the accessory hearts of Hancock, the strand-like spermaries, the pallial circulation, the life attitudes of different forms, and particularly the varied and graceful movements of the brachia. The strand-like spermaries and the pharyngeal glands are characters heretofore undescribed, and further details are given regarding the external glands first described by the author. The presence of otocysts in *Lingula* and *Glottidia* are definitely shown although Blochmann has doubted their existence in these genera. The organs described by Hancock as the 'heart' and the 'accessory hearts' have been frequently investigated by various observers, but no final conclusion has been reached. The author shows that they cannot well belong to the circulatory system, but must be regarded as in some way connected with the genitalia, though their precise functions have not yet been

determined. The plates accompanying this memoir were drawn by the author in his usual clear and artistic manner. They represent just what is intended to be shown, and are evidently depictions of natural objects." (Science, Dec. 5-1902, pp. 901-902).

TIMBER LINES.*

By ISRAEL C. RUSSELL, Ann Arbor, Mich.

"Timber-line" as commonly defined, is the upper limit of arboreal vegetation on mountains. Its position is determined mainly by the occurrence of a mean annual temperature of about 32 degrees Fahrenheit, but locally its elevation is regulated by soil conditions, and by differences between various localities in snow-fall, severity of winter storms, exposure to the sun, etc. It may with propriety be termed the "cold timber-line." Above it on high mountains, there is commonly a region occupied by alpine flowers, and still higher a region of perpetual snow. When traced from warm to colder regions, or in general from equatorial toward polar regions, it becomes lower and lower; in North America it descends nearly to sea level in Alaska and northern Canada, where it defines the northern limit of the sub-arctic forest and becomes the "continental timber-line" to the north of which lie the barren grounds and tundras, which correspond to the zone of alpine flowers on lofty mountains in temperate latitudes.

On some of the mountain ranges of the arid portion of the United States, there is a lower limit of tree growth, the position of which is determined in the main, by insufficient moisture, and locally by soil conditions, including the presence of alkali, hot winds, forest fires, exposure to the sun etc. This may be termed the "dry timber-line." Below it are treeless, grass-covered plains and valleys. On the mountains of central Idaho, the cold timber-line is sharply drawn at an elevation of about 10,000 feet, while the dry timber-line, equally well defined, has an elevation of about 7,000 feet; between the two there is a belt of forest trees which encircles the mountains. In southeastern Oregon, Nevada, southern California, etc., where the climate is excessively arid, the dry timber-line is

*Abstract of a paper read at the late meeting, G. S. A., at Washington, D. C.

higher than in Idaho, and in certain localities meets the cold timber-line and the mountains are bare of trees from base to summit. The dry timber-line decreases in elevation when traced from arid to humid regions. In the central part of the continental basin of North America, it defines the border of the treeless portion of the Great Plateaus and the prairie plains, and at the north coincides with the southern limit of the subarctic forest. On the borders of the treeless plateaus and the prairie plains the position of the margin of the encircling forest is determined mainly by lack of moisture, but is varied locally by soil conditions, hot winds, forest fires etc., in the same manner that the lower limit of tree growth on the mountains of arid region is regulated.

When the humidity is sufficient for the growth of trees, as for example on the mountains of New England, the dry timber-line disappears. An arid region may be bordered at a lower elevation, by a region with sufficient humidity to permit trees to grow, and may then be bordered both above and below by the dry timber-line, as is the case in Idaho. Where an arid region reaches sea level as in Arizona, southern California, and the west coast of Mexico, etc., there is no forest below the arid belt, and in certain localities the dry timber-line meets the cold timber-line, and the mountains are bare of trees from sea level to their summits.

There is also a third general cause which draws a limit to timber growth, namely, excessive humidity, as for example on the borders of swamps, the margin of lakes etc., which may perhaps be termed the "wet timber-line."

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Report of the state geologist on the mineral industries and geology of certain areas of Vermont. Third of this series. 1901-1902. GEO. H. PERKINS.

Besides sketches of two early geologists of Vermont (Thompson an Wing) Prof. Perkins has presented in this excellent report, with many vivid half-tone plates of natural geologic scenes, more full and accurate descriptions than have ever before been published, of some of the important points in the geology of Vermont. There is a special

study of the granite of Barre, Vermont, with a geological map of Orange county, with parts of contiguous counties. This map shows twenty-five isolated small areas of granite, the chief of which are in the geographic area of the Washington limestone, or marble. This limestone has been hitherto considered Upper Silurian, (Dana) but Dr. C. H. Richardson, who contributes this chapter, shows by the discovery of fifteen species of fossils that it is of the age of the Lower Trenton. He also remaks that so far as Orange county is concerned there is no appearance of non-conformity between the eastern slate (the bottom of the Trenton) and the western (the culmination of the period), but the succession is continuous from east to west. "If ever such relations are found between upper and lower Silurian terranes of eastern Vermont, I am confident that it will be in the vicinity of lake Memphremagog.

Prof. Perkins gives a full description of the geology of Grand Isle, of the Champlain valley, on which is found a series of strata running from the Beekmantown to the Utica, accompanied by a geological map of the island. He was assisted by Prof. H. M. Seely who has rendered a discussion of the sponges of the Chazy formation, and H. W. Shimer who has petrographically examined the dikes of the island. N. H. W.

Magnetic declination tables, and isogonic charts for 1902, and Principal facts relating to the Earth's magnetism. L. A. BAUER. U. S. Coast and Geodetic Survey. O. H. TITTMAN. Superintendent. Washington, 1902.

This valuable document should be in every geologist's library. The long series of magnetic observations conducted, or collected, by the United States Coast and Geodetic Survey, begins to bear fruit of high scientific value. Other publications of the survey have isogonic charts of equal magnetic declination, but this volume not only is a compend of all previous data and tables, but contains an instructive presentation of the progress of knowledge concerning the magnetism of the earth beginning with the the earliest mention of the magnet or lodestone and its polarity, the discovery and improvements of the mariner's compass, the dipping action of the needle, the discovery of Gilbert in the sixteenth century that "the earth itself is a great magnet," the causes thereof, the declination of the magnetic needle, the secular change of the magnetic declination discovered by Gellibrand in 1634, the secular variation of dip and of intensity of the magnetic needle, the time intervals between extreme positions of the needle, the irregularities of the same, the general *clockwise direction* of the secular variation of the north end of the needle, the diurnal variation of the magnetic declination, its variation with the sun-spot period (11 years), annual variation of the magnetic declination, its cause or causes are outside the earth, magnetic storms, their relation to solar activity, to earth's cataclysms, (earthquakes and volcanic outbursts) and to electric currents in the upper regions—these topics, and the ways and means of recording magnetic observations,, especially in the United States, and charts expressing the geographic zones of variation, are lucidly presented by Dr. Bauer in an introductory chapter. The body of the volume is taken up with a record

of magnetic declination in the United States and outlying territories reduced to Jan. 1, 1902, and by descriptions of the magnetic stations.

N. H. W.

Iowa Geological Survey, Volume XII, Annual Report, 1901, with accompanying Papers. SAMUEL CALVIN, State Geologist; A. G. LEONARD, Assistant State Geologist. Pages 511; with 6 folded maps, 11 plates, and 78 figures in the text. Des Moines, 1902.

The administrative report of the state geologist, in pages 11-27, shows that the Survey had been completed in fifty-three counties, and was in progress in eight others, leaving thirty-eight counties in which it had not been begun.

The Mineral Production of Iowa in 1901 is reported by S. W. Beyer, in pages 37-61, its total being $12,204,160. Its several parts of chief importance were as follows: coal, $8,051,806; clay products, $2,774,200, stone, $781,750; gypsum, $562,500; lead and zinc, $16,500; and iron ore, $4,876. Each was considerably increased above the production for the year 1900, the aggregate increase being about $1,800,000.

This volume contains reports on the geology of six counties, namely, Webster county, by Frank A. Wilder; Henry county, by T. E. Savage; Cherokee and Buena Vista counties, by Thomas H. Macbride; Jefferson county, by J. A. Udden; and Wapello county, by A. G. Leonard.

Webster county is of exceptional economic interest on account of its extensive mines of coal and gypsum. An area of 60 to 70 square miles is occupied by the gypsum deposit, which varies in thickness from 10 to 25 feet, directly underlying the glacial drift. It is regarded as probably of Permian age, but possibly Triassic or Cretaceous. This chapter treats quite fully of the commercial uses of gypsum, giving details and statistics of its manufacture as plaster, and of its production in other parts of the United States, in Canada, and in European countries. It is followed by an important paper, in pages 193-223, on the Gypsum Industry in Germany.

Each of the other counties described has many interesting features of stratigraphic geology and of the glacial drift series. Although Iowa has contributed much to the discovery of the complex history of the Ice age, much also yet remains to be ascertained, by further observations and discussion, concerning the mode of deposition, ensuing erosion, and age, of its successive drift formaations.

W. U.

A System of Glacier-Lakes in the Cleveland Hills. By PERCY FRY KENDALL, Lecturer on Geology at the Yorkshire College, Leeds, England. (Quart. Jour. Geol. Soc. vol. lviii, pp. 471-571, with pls. xx-xxviii; August, 1902.)

The area here described is the northeast part of Yorkshire, adjoining the coast of the North sea from Filey Brigg, near Flamborough head, northwesterly to the river Tees, and reaching back from the coast about thirty miles. The ice-sheet that overspread Scotland and Ireland, the basin of the Irish sea, and northern England, flowed to the western and northern borders of this area; and on the east the confluent Scottish and Scandinavian ice-sheets pushed their margin across

the present coast line, advancing upon the land to a distance that varies from two to eight miles. Thus obstructed, the valleys and dales of this hilly district held many glacier lakes, as shown by the channels of their outflow over present lines of watershed. Lake Pickering, 24 miles long from east to west and 8 miles wide, was the most southern and the largest of these ice-dammed lakes; and lake Eskdale, joining with the Kildale lake, in the northern edge of the district, was the second in size, measuring 10 miles in length.

The author finds evidences of a long period of preglacial elevation of this region. During the continuation of that time the European ice-sheet, flowing outward from the Scandinavian peninsula, extended across the entire basin of the shallow North sea, then a land plain, bringing boulders and pebbles from Norway to the English coast.

W. U.

MONTHLY AUTHOR'S CATALOGUE

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PERSONAL AND SCIENTIFIC NEWS.

Dr. H. Foster Bain will give a series of lectures on economic geology before the students of the geological department of the University of Chicago, beginning about February 15th.

Geological Society of Washington. At the meeting of this society held on Wednesday, January 28th, the following program was presented: "The drainage of the valleys of Mexico," S. F. Emmons; "Notes on the geology of Molokai, Hawaiian islands," Waldemar Lindgren.

There is contemplated in the completed system the establishment of two classes of fellowships and two classes of scholarships. The first named group includes ordinary fellowships expected to yield annually about $300.00 each, and the traveling fellowships to yield about $500 and $1000.

The Board of Trustees has already established 90 scholarships divided into two groups.

Fifty scholarships, each yielding about $100 annually, are open to students living in the United States. They are held for one year. These scholarships are assigned during the first semester of each academic year.

There is one scholarship for each state in the Union. The student from each state passiug the best examination for entrance to the School, or to advanced standing, or furnishing evidence of best qualifications to carry on the work in this institution, is awarded the scholarship for that state. The state scholarships are bestowed upon the following conditions:

1. The application must be made in writing before May 1 of the academic year preceding that in which the scholarships are awarded.

2. Accompanying the application should be a short statement of the candidate's previous training, and an indication of the course he wishes to pursue.

3. Applicants for the state scholarships are expected to proceed to the engineer's degree.

4. Holders of scholarships are not exempt from laboratory fees.

In case in any one year worthy condidates do not offer themselves from any one state, the Board at its option, reserves such appointments, or awards them to applicants from other states, preference being given to students who already hold college degrees, or who present evidence of unusual attainmnts in mining studies.

Forty scholarships, each yielding $25 a year and open to students who are actually residents of New Mexico. They are good for one year; and are bestowed at the beginning of each academic year.

These scholarships are awarded to the two students from each county in New Mexico passing the best examinations for entrance, or for advanced admission to the School, on presenting evidence of the best qualification for carrying on the work of the course selected.

Examinations must be taken at the regular time at the end or at the beginning of the academic year. As in the case of the state scholarships, the New Mexican scholarships are bestowed as honors, as incentives to good work. Holders of scholarships are expected to proceed to a degree.

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THE

AMERICAN GEOLOGIST.

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THE I. H. HARRIS COLLECTION OF INVERTEBRATE FOSSILS IN THE UNITED STATES NATIONAL MUSEUM.

By CHARLES SCHUCHERT, Washington.

PORTRAIT—PLATE XI.

In the winter of 1897-1898, the National Museum received by bequest a very valuable private collection representing the Lower Silurian faunas and the archæology of southwestern Ohio. This collection is the result of nearly fifty years of untiring effort on the part of Mr. Israel Hopkins Harris, and it is fitting to give here an account of the builder and his collection, now that the fossils have reached their final destination in the National Museum.

Mr. Israel Hopkins Harris was born in Centerville, Montgomery county, Ohio, November 23, 1823, and died October 17, 1897. His ancestors were New Englanders and his grandfather settled in Centreville, Ohio, early in the last century. At this place his father, James Harris, was born in 1801 and in early manhood became a prominent merchant at Waynesville, Ohio. His mother was Rebecca C. Jennings of Gloucester, New Jersey, of an English family tracing their lineage back to the time of the Conquest.

The subject of this sketch was the oldest of five children and entered Yale College in the Junior class of 1844. Graduating in 1846, he took charge of his father's business, and in 1855 became the junior partner of the banking firm of Stokes and Harris. This firm was continued until 1868, from which time until 1897 the Exchange Bank of Waynesville, Ohio, was carried on by Mr. Harris.

At Yale Mr. Harris received his training in geology from the elder Silliman. This study so fascinated him that shortly after leaving college he applied himself, as well as his business permitted, to the geology of southwestern Ohio. For nearly fifty years he gathered the well-preserved fossils of the Cincinnati group and accumulated the most extensive collection extant of the rarer forms, as star-fishes, cystids, crinoids, and trilobites.

The bulk and most valuable part of the I. H. Harris collection consists of fossils from the upper half of the Cincinnati group, there being represented from the entire series of beds about 570 species out of a total of about 1,000 known forms from the Cincinnatian strata, of which from 100 to 150 are new species.

The Bryozoa are particularly well represented by an abundance of carefully selected specimens, the result of at least ten years collecting by Mr. Ernst H. Vaupel, a special student of this class of organisms. Many new species are present.

The starfishes, as is well known, are the rarest of Paleozoic fossils, and Mr. Harris fully appreciated this fact. The discovery of a piece of a starfish would lead him to set a laborer to dig for days, and in more than one case was he thus enabled to secure entire individuals. By constant watch for these choice fossils, he eventually secured about fifty specimens, and there is no better preserved material than this in the Harris collection. The writer hopes soon to publish a monograph of these fossils.

Of those peculiar Pelmatozoa, the *Edrioasteroidea* (*Cyclocystoides, Cystaster, Hemicystites, Lepidodiscus,* and *Streptaster*), the collection has more than 200 specimens, many of which are quite perfect.

Of crinoids, the collection has, after removing the duplicates, about 1400 specimens of the genera *Anomalocrinus, Compsocrinus, Dendrocrinus, Ectenocrinus, Glyptocrinus, Heterocrinus, Isocrinus, Merocrinus, Ohiocrinus, Ptychocrinus, Pycnocrinus, Reteocrinus, Rhaphanocrinus,* and *Xenocrinus.* The great scientific value of this unique series is further enhanced by the presence of twelve large and unique slabs, each showing from ten to thirty specimens. One of these has

a total of twenty-five specimens of *Rhaphanocrinus sculptus, Dendrocrinus casei, Composocrinus miamiensis,* and *Xenocrinus baeri,* all of which are rare species. Of *Xenocrinus penicillus,* Mr. Harris secured the entire colony, and specimens now in other museums than the National Museum are a part of the original lot. It is, without doubt, the most select and extensive series of Cincinnatian crinoids ever assembled.

The trilobites are also well represented, since more than 300 specimens are present illustrating the genera *Acidaspis, Ceraurus, Dalmanites, Isotelus, Lichas, Proctus, Triarthrus, Trinucleus* and more than 2,000 specimens of *Calymene callicephala.*

Another very valuable feature of Mr. Harris' work was the great care he gave to cleaning and labelling the material, which enabled the writer and Mr. R. S. Bassler to locate accurately all the specimens in the twelve zones of the Cincinnatian group as recently defined by Mr. John M. Nickles. The collection as now recorded will have a permanent value, not only to the morphologist, but to the detailed stratigrapher as well.

From the celebrated crinoid locality at Crawfordsville, Indiana, there are several hundred fine specimens and a smaller but good series of crinoids from Burlington, Iowa. Other places well represented are Waldron, Indiana, and the famous Carboniferous plant locality of Grundy county, Illinois. From these localities there are about 180 species.

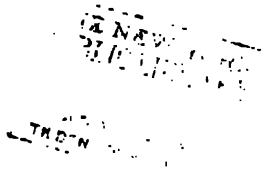
Paleontologists have not failed to recognize Mr. Harris' work, and in the record we find that S. A. Miller named four species in his honor and James and Ulrich one each. These belong to the genera *Compsocrinus, Cyathocrinus, Lichas, Palaeaster, Helopora,* and *Calloporella.*

The collection of fossils as now arranged in the National Museum is divided into two series, an exhibition and a study series. The exhibition series has about 3,400 of the best and most showy specimens, mounted on 365 tiles or blocks, while the study collection is kept in 56 large drawers, and is not on exhibition. Together both series are recorded on the Museum register under 1,250 numbers, representing about 750 species and 17,000 specimens. Of these, 26 species are represented by either the original type or figured individuals.

The archæological specimens, many thousand in number, are now being studied and arranged for exhibition, and will be described at another time.

Some years ago, when the writer resided at Cincinnati and was associated with Mr. Ulrich, the enthusiasm of our youth led us to plan a monograph of the fossils of the Cincinnati group, and in this plan the Harris collection was largely to serve; but the cost of production was so great that the work had to be reluctantly abandoned. Since then, the U. S. National museum has or will acquire the collections of I. H. Harris, E. O. Ulrich, Charles Schuchert, Ernst H. Vaupel, Henry E. Dickhaut, and Ray S. Bassler. It is safe to say that, during the next few years, the national collection of Cincinnati fossils, after removal of the duplicates, will contain not far from 50,000 specimens and will be the most extensive in existence. The plans of our younger days will again be brought forward when the above mentioned collections have received their preliminary arrangement.

In this connection, it is gratifying to note what the Cincinnati region has done for American paleontology. The well preserved and abundant fossils of this region have attracted and made many a local collector, the attraction, as a rule, beginning with his school days. It would not be difficult to give a list of fifty names of such workers, and twenty-five years ago the writer knew not less than twelve other boy collectors about Cincinnati. For the sake of noting the apparent fact that environment has much to do with the making of paleontologists, only those collectors who have enriched the science by collections or publications will be named. These, somewhat chronologically arranged, are: Dr. John Locke, David Christy (author of "Christy's Letters on Geology," 1848,) F. B. Meek (Madison, Ind.), S. T. Carley, U. P. James, C. B. Dyer, S. A. Miller, A. G. Wetherby, John Mickleborough, Joseph L. Moore (Richmond, Ind.), Dr. Richard M. Byrnes, Dr. H. H. Hill, I. H. Harris (Waynesville, Ohio), Dr. L. B. Welch (Wilmington, Ohio), Dr. W. S. T. Cornett (Madison, Indiana), J. Kelly O'Neall (Lebanon, Ohio), Mrs. Mary P. Haines (Richmond, Indiana), E. O. Ulrich, Joseph F. James, Charles Schuchert, John M. Nickles, E. H. Vaupel, H. E. Dickhaut, T. J. Patterson, D. A. McCord (Oxford, Ohio), G. W.



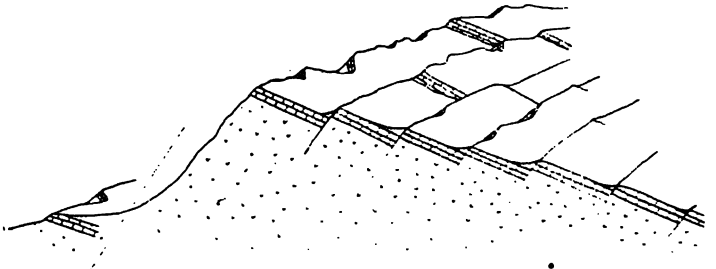


FIGURE 1.

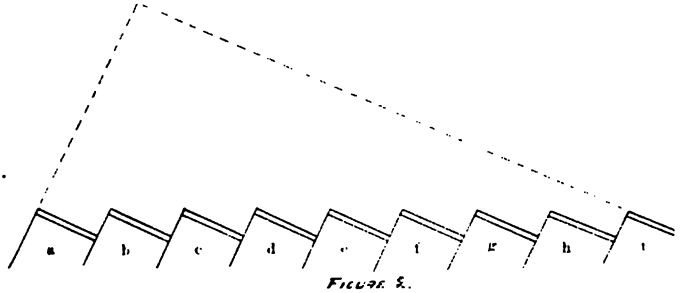


FIGURE 2.

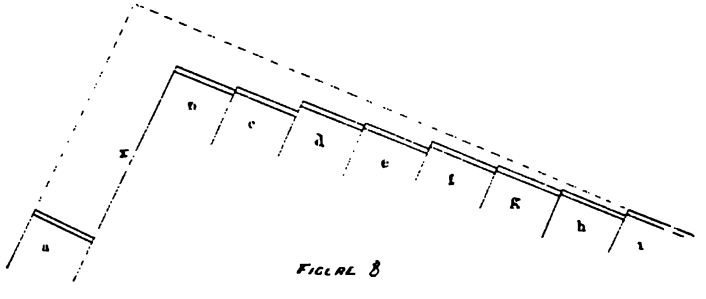


FIGURE 3

BLOCK MOUNTAINS IN MEXICO.

Harper, George Oeh, C. L. Faber, Dr. D. T. D. Dyche (Lebanon, Ohio), John Misner (Richmond, Ind.), R. S. Bassler, Dr. George M. Austin (Wilmington, Ohio), John Hammell (Madison, Ind.), A. Albers, George Asherman, George C. Hubbard (Madison, Ind.). Truly, no other region has developed so many collectors, paleontologists, and stratigraphers!

A retrospect of the past twenty-five years, however, brings out another fact, namely, that the natural conditions alone will not produce a large crop of collectors. There must be also personal stimulus and example, and today the Cincinnati hills, although as rich in fossils and far more accessible than in the days of horse cars, have no adequate band of workers. It is true that here and there a new collector is attracting attention, but the teachers and exemplars of twenty years ago, as Miller, James, Wetherby, Hill, and Byrnes, are no longer present. The Cincinnati Society of Natural History can again be this stimulus, as it was twenty years ago, and it is to be hoped that the present curator may receive the abundant support of the citizens of the Queen City of the West.

U. S. National Museum, January, 1903.

BLOCK MOUNTAINS IN NEW MEXICO.

By Douglas Wilson Johnson.

PLATE XII.

At the recent meeting of the Geological Society of America in Washington, D. C., the papers of G. K. Gilbert, W. M. Davis, and M. R. Campbell on the basin-range structure of mountains led to a discussion of the detailed nature of block-faulting and some phenomena connected therewith. It was suggested by C. R. Van Hise that where such faults occur, the disparity in position of the strata on either side of the fault is brought about, not by a single great drop or upthrust, but by a more or less extensive series of parallel breaks. This Van Hise terms a "distributive fault," and he regarded such a fault as the usual if not necessary agent in the formation of mountains of the basin-range type. Davis was of the opinion that in the cases cited by him one great fault along a single

plane would explain the phenomena observed, altho the existence of other parallel faults was regarded possible. In some of the cases cited by Gilbert the existence of several such fault planes was shown.

The presentation of these papers, and the discussion which followed, recalled to the writer's mind some few observations made in the mountains of central New Mexico during recent years, and while they may add nothing really new to what is already known of block-faulting, they are here recorded as of possible passing interest.

Twelve miles east of the city of Albuquerque rises the abrupt western escarpment of the north and south range of the Sandia mountains, to a hight of over five thousand feet above the level of the city, or over ten thousand feet above sea level. The range consists essentially of a great monoclinal uplift of granite and metamorphosed sedimentary rocks, capped by easterly dipping limestones and sands of Upper Carboniferous age. The western face is steep and rugged, presenting a very bold and striking topography. The eastern slope is very gentle, and comparatively smooth and unbroken. The western base of the range is fairly regular along the north and south line, altho this regularity is somewhat obscured by the advanced stage of erosion and the great alluvial fans which extend well up into the cañons.

At the base of the western escarpment occurs, exposed in several places, limestone from which Dr. C. L. Herrick collected a few poorly preserved fossils of Carboniferous age. This limestone on the western side of the great fault plane appears to be the equivalent of the beds capping the range on the eastern side of this plane, and indicates a fault of more than three thousand feet. A few miles further south, along the base of this same monoclinal uplift, we find the Red Beds of still later age, exposed just at the base of the escarpment. It is thus evident that the great movement which gave to the mountain its precipitous western face was along this one plane, or at least along a series of parallel planes confined to so narrow a zone as to constitute, for all practical purposes, but one single plane. No evidence of more than one such plane was seen.

This great fault along one prominent plane, however, was only one of a large series of parallel faults more or less closely associated. How many such faults lie buried beneath the alluvium to the west is of course unknown, but just west of Albuquerque, at a considerably lower level than the Carboniferous limestone beds at the base of the mountains, are exposed easterly dipping sands which have been referred to the Tertiary by Dr. Herrick; while still further west, on the same level with these sands, the Cretaceous is shown. The contact between the Tertiary and Cretaceous is interesting in this connection, as it is along a broad fault belt, the belt being characterized by a beautiful set of easterly dipping blocks faulted along a series of parallel planes.

But this faulting was not confined to the region west of the scarp. While, as stated above, the eastern slope of the mountain is *comparatively* smooth, a closer examination shows that it is broken by a series of blocks faulted along planes parallel to the main escarpment, as well as along vertical planes more or less nearly at right angles to these. In fact, the whole eastern slope is covered with duplications, in miniature, of the entire great uplift. As these faults are usually normal, the summit of the range is really formed by those blocks of this smaller series which have dropped down (comparatively) the most. The essential figures are shown in the diagram (fig. 1.).

This same structure is shown still more beautifully in the Magdalena mountains, seventy-five miles further south, where the development of extensive lead-silver mines has afforded excellent opportunity for the study of detailed features. Here again the range consists of a great monoclinal uplift, whose abrupt granitic escarpment faces eastward, while the more gentle slope of the limestone beds is toward the west. When seen from the northwest, the beautiful series of the smaller limestone blocks stand out with diagrammatic clearness. The faults are in most cases normal (I have seen a few exceptions) so that the series of these blocks which have dropped down (comparatively) the most, are the highest in the range. As in the case of the Sandias, these blocks are also faulted along lines more or less nearly at right angles to the main series.

In this limestone series there are two zones that have proven rich in lead-silver ores. It was the block-faulting which made the ores accessible, and it is this same faulting which has caused endless trouble in following out the ore chutes. Again and again the ore is cut off by a fault and the miner must work up the fault plane until the ore zone is again located in the adjacent block, or else tunnel through barren rock until that zone is reached. Besides the faults producing these blocks there are innumerable smaller ones with but slight displacement.

It would seem, then, that in the cases cited the total displacement was brought about, not by a single fault, but by a very large series of parallel faults,—a series not to be numbered by tens or hundreds, but more probably by thousands, if we take into consideration the vast number whose displacement is so slight as to be apparent only to one tracing out with care some mineral vein. Nor do I believe that we can leave wholly out of account the progressively smaller movements which have for their ultimate expression molecular displacement. Along some plane, however, the strain has been greater in proportion to the ability of the rocks to resist, and the displacement along such a plane has been correspondingly greater. To this fact we owe the existence of the mountain form.

From the standpoint of structure, this mountain form must be considered as purely accidental. It is easy to conceive that if we have a series of strata yielding to extreme pressure, the displacement might be somewhat equally distributed along various parallel fault planes, giving us typical block-faulting in which the several blocks (a, b, c, etc.) would be comparatively small, and no mountain form would be produced. (fig. 2.) Instances of this nature are frequently seen in the field.

Now if we conceive the displacement along the several planes to have been only one-third as great as represented above, except in the case of some one fault plane as x, where we may consider all the additional displacement to have taken place, we have the conditions represented in fig. 3, where a true monoclinal mountain form is produced.

This is exactly the condition we find in the cases of the Sandia and Magdalena mountains above referred to.

By a comparison of the dotted lines in figures 2 and 3 it will be seen that the total displacement (between a and i) is exactly the same. The nature of the displacement is the same. The only difference is one of quantitative distribution. Of course any combinations of variations between these two extremes may, and many do, occur.

Van Hise has emphasized the fact that the same displacement may be brought about without any definite faults being produced, as a result of numerous minor slips along planes of fissility, so that the deformation is spread over a considerable area. If such deformation were confined to a comparatively narrow zone the mountain form might be produced, while if it were wide-spread enough, no such form would result. In the same way a given displacement may be brought about by step-faulting with or without the production of mountain form.

SOME EVIDENCE OF TWO GLACIAL STAGES IN THE KLAMATH MOUNTAINS IN CALIFORNIA.

By Oscar H. Hershey, Berkeley, California.

Introduction.

In the early part of last summer, the operations of the Trinity Gold Placer Mining Syndicate, Limited, in its hydraulic mine at the junction of Union and Coffee creeks, in Trinity county, California, brought to light two tusks of one or more large animals, either mastodon or elephant. Such remains are rather widely distributed and frequently found in California, but the writer early recognized the more than usual importance of this find because of the altitude of the locality, the ruggedness of the country, and the fact that undoubted glacial deposits were known to occur on Union creek within one and one-half miles of the mine, so that careful study of the vicinity might furnish data for determining whether the animal or animals lived before, during or since the "Glacial Epoch" of California Quaternary geology.

The property is popularly known as the Nash mine, from a former owner. Through the courtesy of the superintendent, Mr. William Maitland, who takes a lively interest in the local geology, I have been furnished with important information in

regard to the deposits in the mine and have been given an opportunity to examine the locality more carefully than formerly. The result has been, to my surprise and gratification, the discovery that the Union Creek glacier once extended to and covered the site of the Nash mine and that *the tusks were found embedded in an old soil formed at the surface of a glacial till.* Incidentally, evidence was gathered of two stages in the glaciation of this region and to give others the opportunity of judging of its value is the object of this paper.

THE FOSSILS.

The first tusk, when found, was intact, but was broken into a number of pieces in the process of removing it from the matrix. These were placed in nearly their relative positions and photographed. No means were taken to preserve the tusk and it has long since fallen to pieces and disappeared. Its length was about six feet. In cross-section at the thickest place, it was about nine inches from top to bottom and about eight inches in width. The sides were flattened. It gradually tapered until near the smaller end which was more than ordinarily blunt from wearing. It curved upward until near the smaller end which was bent to one side, presumably outward. It was hollow for about 18 inches from the larger end. Internally, it was concentrically laminated. The material was a soft, fine, whitish, greasy substance—partly decayed ivory.

The photograph and a small fragment of the tusk were submitted to Mr. William Sinclair of the State University of California, the Pacific Coast expert on fossils of this class, who considers it fairly certain, from the curvature and the internal structure (not the lamination above mentioned) that the animal was an elephant, *Elephas primigenius.*

The second tusk was similar to the first except that it was slightly smaller. Means were found to preserve a portion of it. The three-foot section now remaining has a curvature of nearly 90°. Disregarding the difference in size, I am strongly inclined to consider both tusks as remains of the same animal. They were found in the same section of the mine and no other tusks were found there or anywhere else in the mine. Associated with these tusks were bunches of a whitish, rotten substance, apparently remains of the bones. To facilitate the

discussion, I will assume that a single elephant was wrecked on that spot.

THE DEPOSITS AT AND IN THE VICINITY OF THE NASH MINE.

Coffee creek, along this section of its course, has a general direction from west to east. About seven miles from its head, it is joined on the south by an important tributary, Union creek. In the main valley, several hundred yards above the junction of the two creeks, a point projects from the north slope. On its down-stream side is situated the present hydraulic mine. This point covers a remnant of an old channel. The channel gravels resting on the bed-rock at the foot of the bank and constituting the "pay streak" are a rather coarse, well water-worn creek deposit, five to fifteen feet thick.* It includes a considerable number of cobbles and small boulders of the Courtney granite. This rock is a peculiar coarse-grained, non-hornblendic granite which cannot be confused with any other and which is confined in place to Mt. Courtney at the head of the present South Fork of Salmon river. In a paper on "Ancient Alpine Glaciers of the Sierra Costa Mountains in California,"† I showed how, largely through the operations of the Salmon River glacier, the upper four or five miles of the original Coffee creek was cut off and added to the Salmon river system. Before this beheading, Coffee creek rose at the foot of Mt. Courtney and the Courtney granite was distributed along the valley to and below the site of the Nash mine. At the time of the maximum extension of the Salmon River glacier as described in the above mentioned paper, it was carrying Courtney granite to the headwaters of the present Coffee creek but its overwashed gravels are fine and there is no reason for believing that the Courtney granite at the Nash mine was derived from that source. The size of this first channel and the abundance of Courtney granite in small boulders make it reasonably certain that the deposit was formed by Coffee creek before its shrinkage through beheading, and it may be considered essentially pre-Glacial so far as California glaciation is concerned. However, it is not nearly as old as the "high-level channels" of the Sierra Nevada re-

* Nearly all the figures in this paper are given from memory and may not be quite accurate, but the discrepancy will not be sufficient to vitiate the arguments.

† *Journal of Geology*, vol. viii, No. 1, pp. 42-57.

gion, as evidence is not wanting that its deposition immediately preceded glaciation.

Overlying the gravel is a heterogeneous agglomeration of small boulders, cobbles and pebbles embedded in a rather stiff clay. It is not distinctly stratified and does not show the sorting action of water; nor is its constitution of the local character of a landslide deposit. I was at first unwilling to recognize it as a glacial deposit, although Mr. Maitland had informed me that Mr. E. B. Preston of the State Mining Bureau had so declared it years ago. A search soon presented unmistakeable evidence of glacial action. Many of the included pebbles and small boulders are of serpentine, a rock peculiarly favorable to the preservation of glacial scratches. Not a few of them are unmistakably striated and flattened. These scratches were not produced in the operation of mining as I made sure by digging pebbles from the undisturbed bank and finding striæ on their bankward sides. These striæ are seemingly not as fresh appearing as usual in the glacial deposits which I have formerly described from these mountains, but the derivation of this idea may have been somewhat influenced by other considerations.

The constitution of the deposit shows that the glacier which formed it did not come down the Coffee creek valley, because in that case the till should be abundantly supplied with hornblende schist, the predominating formation of the main valley, whereas the included rock fragments are chiefly of serpentine, the vastly predominating formation of the Union creek valley. At the junction of the two valleys there is a projecting narrow point of mica schist. The Union creek glacier over-rode this ridge and plunged down into the narrow valley of Coffee creek. The ice abraded the upper portion of the creek gravels and incorporated them into its own peculiar till. In this manner some of the Courtney granite boulders became included in the glacial deposit. Near the junction between the creek gravel and the till, the former is much broken up and at only a few places is there a sharp line between them.

The till varies in thickness from five to fifty feet, and has been piled up into a slight moraine marking the former extent of the glacier. In fact, it is the end of a discontinuous lateral moraine. Near the base the till preserves its original dull

bluish color derived from the large constituent of ground serpentine, but oxidation has penetrated to a depth of fifteen to twenty feet, the color near the surface being a light reddish brown and below this a yellowish brown without the red tint. Such a deep oxidation and reddened surface I have not observed in the similar deposits of the Swift creek or other glaciated valleys of these mountains. It is one of the chief factors in giving this deposit the appearance of considerably greater age than any glacial deposit which I have heretofore described from this county.

About 1000 feet below the Nash mine buildings, the old valley of Coffee creek, several hundred feet wide, is obstructed by a slight moraine of serpentine debris, with some gabbro and a few granite boulders of fine grain occurring in place at the head of the main Union creek valley. The moraine is probably 100 feet high and 300 feet wide. Its topography is not distinctly morainic and I had long considered it a landslide, but a more thorough examination of its interior afforded by a deep cutting, revealed its glacial character.

Above the obstruction the valley has the form of a basin about 1200 feet long and 300 to 600 feet wide, entered on the south by the narrow valley of Union creek. This basin was the floor of the glacier. On issuing from the narrow Union creek valley, the glacier spread out like a fan, turning up the main Coffee creek valley a short distance and forming the short moraine at the mine; and flowing down the valley a little farther to form the short moraine at the obstruction mentioned above. The Coffee creek valley both above and below those points presents no evidence of glacial action except near the head.

Immediately upon the retreat of the glacier from its maximum extension, the deeper portion of the basin was occupied by a glacial lakelet, such as are commonly found in all recently glaciated regions. This lakelet probably occupied between five and ten acres. A considerable remnant of its deposits has been uncovered and beautifully exposed by the mining operations. It is a bed of dark brown, finely laminated, non-pebbly horizontal silt, ten feet in thickness. It abounds in vegetable debris such as fir leaves and small pieces of driftwood. Precisely similar deposits are now forming in the glacial lakelets of the higher valleys.

A red soil was found at the surface of the till surrounding the lake, but close to the immediate border this soil received an intensely black stain and was probably marshy. The elephant remains were found in this soil just beyond the margin of the silt deposit and it is reasonable to suppose that the animal came to its death by approaching the lake and miring down into the marshy soil on its margin. The animal remains did not arrive at their position in this glacial deposit by the action of the glacier as it is beyond dispute that the tusks would not have remained unbroken or unabraded. Further, as already shown, the association of the remains indicates that the animal actually lived and died on that spot. Being within the glacial basin, this must have occurred after the maximum extension of the glacier. After the destruction of the lakelet, the soil was no longer marshy and the conditions were not so favorable for the incorporation within it of the remains of a large animal. The question of the probable age of the elephant is, therefore, reduced rather narrowly to that of the lakelet.

The Coffee creek passes the obstruction at the lower end of the basin in a gorge cut through a massive serpentine point on the north of the old valley. It has an estimated length of 500 feet, a depth of 100 feet, a width at the bottom that of the creek, 20 to 30 feet and at the top 200 feet. Sheared serpentine is a formation easily eroded, but massive serpentine resists erosion well. In this respect it is comparable with granite and other very hard rocks of this region. The gorge is cut through a particularly resistant portion of the serpentine mass and its steep walls are encumbered by large angular blocks of this rock. The gorge cutting has required a considerable time and this is the measure of the time since the maximum extension of the Union creek glacier. This gorge constitutes the most important part of the evidence that glaciation in this region has been much more complex than I have heretofore supposed it. Unfortunately, I have no standards with which to compare this gorge to arrive at its absolute age and all I can do is to show the probability that it is much older than rock gorges occurring nearer the heads of the glaciated valleys.

The silt deposit at the Nash mine is so situated with reference to this gorge as that the lake was completely drained long

before the gorge was cut down to nearly one-half of its present depth. The stream flowing from the lakelet was a large one, carrying the combined waters of Coffee and Union creeks, but as it was nearly free from sediment, its erosive power was not great. Hence, it probably occupied a longer time in making the cut which drained the lake, than in doing an equal amount of work since, but it has done so much more work since that it is quite safe to place the destruction of the lakelet farther back than one-half of the time since the maximum extension of the Union creek glacier.

That the lakelet disappeared long ago is also evidenced by the changes that have since occurred in the basin. Over the silt there is a deposit of coarse gravel and boulders made by Coffee creek after the destruction of the lake. The creek has excavated a new trench through this gravel and the underlying silt, leaving remnants of them on its northern side. This latest trench is several times as wide as the stream and is floored by a sort of modern alluvial plain. Compare this complex history with that of the glacial lake basins near the heads of the glaciated valleys. The latter are so fresh that in no case observed has a large one been drained by the cutting of a gorge through the rock barrier below. Some of these lakelets are held by barriers of till. In my former paper on the ancient glaciers of this region I have given a number of facts proving the comparative recency of most of the glacial action in these mountains and I will not repeat them.

The stream which drained the lakelet under discussion was a much larger one than those flowing from the existing lakelets, and may be expected to have eroded the outlet more rapidly, but making due allowance for this factor, I still think that the lake basin should not yet be completely drained if this lake did not originate long anterior to those now existing in the higher valleys.

A comparison of the changes which have occurred in this lake basin since the destruction of the lakelet, and of the amount of gorge-cutting since that event, with the changes which have occurred near the head of the glaciated valleys since the disappearance of the Pleistocene glaciers, leads to the conclusions that the final draining of the lakelet preceded the end of the glaciation. If the premise that the elephant

whose remains have been found, mired down into the marshy soil on the border of the lakelet be a sound one, it was probably contemporaneous with the Quaternary glaciation of the Union creek valley, provided there was not an interglacial stage of which we as yet know nothing. In fact, I am strongly impressed that the elephant lived very shortly after the maximum extension of the glacier and that if the deposits at the Nash mine represent an earlier stage or epoch of glaciation than those near the head of the Union creek valley, the animal was contemporaneous with the first stage. That is my conviction but for the sake of conservatism I do not like to be too positive in expressing it.

The track of the glacier was followed up the Union creek valley. Along the Union creek ditch of the mining plant, near the penstock 333 feet above bed-rock in the mine on Coffee creek and overlooking the Nash mine, there was found a mixture of rounded serpentine boulders and schist debris embedded in unstratified sandy clay. There was one finely striated boulder. This deposit rests on mica schist, and the serpentine must have been lifted or else brought down the valley a considerable distance. There are several similar deposits along the ditch within the next half mile. They seem to be remnants of a lateral moraine leading directly to the Nash mine.

The trail from the Dorleska mine comes down over glacial deposits until within about one and one-half miles of the mouth of the Union creek valley, at which point there is an appearance of cessation of the glacial action. For the next mile the trail, still high above the creek, traverses a mass of broken rock whose position (partly obstructing the valley) and topography mark it as a gigantic landslide. Following the ditch below the landslide, one finds instead a mixture of rounded and smoothed serpentine boulders and schist debris, with an occasional striated boulder or cobble. Apparently, the landslide has occurred since the glaciation, and its material overlies the glacial deposit. Since the landslide the creek has excavated a cañon at least several hundred feet deep and whose floor is usually only a little wider than the creek, 40 to 50 feet.

At about one and one-half miles from the mouth of the creek, the cañon opens out into a wider valley, characterized

by boulder-strewn flats elevated from 10 to 50 feet above the creek, which latter continues to occupy a narrow but now shallow cañon. Here begin the well marked evidences of glaciation which I had formerly considered as indicating the limit of the glacier. The scanty glacial deposits observed below this point contain very few granite boulders. From here to several miles up the valley the glacial deposit is characterized by abundant granite boulders, and there is otherwise a greater variety of rock species, and in other respects, also, the deposit is one more nearly typical of glacial action. From this point up granite erratic boulders occur on the slopes of the mountains. The glacial nature of this deposit is so glaringly evident that I recognized it immediately upon coming into the region, but the evidences of glaciation farther down the valley are so obscure that I have crossed some of the principal deposits frequently for several years without recognizing their character.

The newer glacial deposit is essentially continuous, and presents glacial topography, very slightly modified, and then only along the stream courses, by erosion. The area of the older deposit shows erosion topography and a very patchy glacial deposit. Its discontinuous character may have been original, but we know that erosion has been active and long continued in its area and the changes have been great.

I am not prepared to assert that there was an intermission of glaciation—an "interglacial stage"—between the maximum extension of the glacier and its final disappearance. There is no clear evidence of it. But some significance must attach to the rather remarkable contrast in the matter of granite boulders above and below the point one and one-half miles from the mouth of Union creek. The source of these boulders is a granite mountain at the head of the valley. Perhaps at the time of the maximum extension of the glacier, the granite mountain was pretty completely buried under snow and subsequently when the glacier was less extensive, granite fragments could more readily shower down on to its surface and be carried to the end. But the sudden cessation of granite boulders in abundance may mean more; it may tell of a radical change in the conditions of glaciation, perhaps even an intermission.

From the size of the gorge below the Nash mine, it appears that the glacial deposit at the Nash mine to too old to be considered of Wisconsin age (the "Glacial Epoch" of California classification). It is certainly not as old as the Kansan epoch, but I am not equally positive that it is not as old as the Illinoian epoch. The same phenomena that I have described, if situated in the Mississippi basin, would indicate the Illinoian epoch. However, making allowance for, we will suppose, severer conditions in this mountain region, I will select the Iowan epoch as the most probable age of these deposits. At the same time I will not assert positively that their deposition was not as recent even as the Early Wisconsin. In such a mountain valley as this, we are dealing with different conditions than in the Mississippi basin, and the standards to which I have been accustomed have to be used with great caution. The inception of the idea that we have here glacial deposits older than the Wisconsin has been so recent to me and so opposes a favorite theory of mine, that I do not yet feel free to subscribe to it without reservations.

Mr. H. W. Turner* encountered apparent glacial deposits in the Sierra Nevada region far below those usually correlated with the Wisconsin drift sheet of the eastern states. They occupy positions which seem to suggest considerable erosion between their accumulation and that of the glacial deposits near the summit of the range. I have understood Mr. Turner to refer them to the time of the earlier series of Wisconsin moraines in the eastern states, but it is possible that they date from an even earlier epoch. Reviewing Mr. Turner's remarks on them, I should say that they are at least Iowan and possibly Illinoian in age. The dual history of the great extinct Quaternary lakes of the Great Basin region leads us to expect evidence of two cold moist periods in the neighboring mountains, and as the second maximum stage of the lakes was contemporaneous with the glaciation whose effects are so glaringly apparent, the earlier maximum stage may be tentatively correlated with the older glacial deposits observed by Turner and with the apparent older glacial phenomena discussed in this paper.

* "The Pleistocene Geology of the South Central Sierra Nevada with especial reference to the Origin of Yosemite Valley." *Proc. Cal. Acad. Sci.*, Third Series, vol. i, No. 9.

Messrs. Delos and Ralph Arnold, as the result of their study of the marine Pleistocene deposits of southern California,* have shown that their Upper San Pedro series contains a semi-tropical fauna, whose relations to preceding and succeeding faunas is of such a nature as to mark that epoch as one of abnormal wildness. On the basis of that series and its correlatives inland and farther north along the coast, I have proposed† to establish a *San Pedran epoch* in California Quaternary geology. This epoch I considered probably of about the same taxonomic value as the Iowan epoch of eastern states geology. But now that I am willing to accept the idea of more than one glacial stage in the California mountains I think it probable that each glacial epoch in the eastern states was accompanied by increased severity in the California climate. It is, therefore, unlikely that a semi-tropical fauna occupied the San Pedro sea while conditions favoring glaciation obtained inland, and probably the San Pedran epoch is the equivalent, in part at least, of one of the inter-glacial epochs of the eastern states. After reviewing the subject of erosion of the San Pedran deposits in southern California, about the bay of San Francisco and in the great valley, I am constrained to place them in the inter-glacial epoch immediately succeeding the Iowan epoch, preferably in its earlier part. The glacial deposit at the Nash mine would then probably fall somewhere within what I have defined as the *Los Angelan epoch.*

The present altitude of the Nash mine is 4250 feet above sea level. In the life of the elephant whose remains have been found there, the altitude may have been more or less, but the ruggedness of the country was equally as great as at the present time. The mountains surrounding the basin are very steep and rocky, and rise 2000 to nearly 3500 feet above the Nash mine. To have ascended the Coffee creek must have been nearly impossible for a large animal as the stream for miles below the mine flows in a narrow, extremely rocky cañon, falling at the rate of 200 to 300 feet per mile. In general character, this region is similar to the "High Sierras" and it is somewhat surprising that an elephant penetrated into it.

* "The Marine Pliocene and Pleistocene Stratigraphy of the Coast of Southern California." *Journal of Geology*, vol. x, No. 2, Feb.-Mar., 1902.

† "The Quaternary of Southern California." *Bull. Dept. Geol., Univ. Calif.*, vol. 3, No. 1, p. 27.

DEPOSITS NEAR THE HEAD OF COFFEE CREEK.

In my paper on the ancient glaciers of this mountain region, I have described the large Salmon river glacier as terminating at a slight morainic ridge which crosses the valley about one and one-half miles from the present head of Coffee creek. Recently I have become aware of the existence below this point of apparent glacial deposits. The creek passes the morainic ridge in an insignificant trench no wider at the bottom than the stream. Then the valley floor suddenly widens to a plain 100 to several hundred feet wide, about which the stream winds in a shallow ditch. This plain has no boulders on its surface. It is composed of the over-wash gravels from the glacier at the time it reached the moraine. It is bounded on either hand by a sort of discontinuous and irregular terrace consisting of boulders, cobbles and other rock debris characteristic of glacial deposits. Serpentine boulders from the east side of the valley higher up, are rather numerous, but Courtney granite is not as conspicuous as in the glacial area above the moraine. The deposit is too coarse to be due to stream action in such a wide and here low grade valley. Many of the boulders are quite angular.

The deposits rise from twenty to seventy-five feet above the valley floor. They extend to at least a mile and a half below the moraine. At that distance, a Courtney granite erratic weighing many tons lies on the valley slope. The terrace-like form of these deposits seems to be due to their remnants of a sheet that once floored the valley, but has been cut away in the central portion by the erosion of a broad trench which was floored by the over-wash deposits of a subsequent glacial stage. Like the supposed older glacial deposits near the Nash mine, *they do not rise high on the slopes of the valley*, which may be significant as the supposed later glaciers appear to have terminated much more abruptly. The generally aged appearance of these deposits and the erosion to which they have been subjected warrant our reference of them to the same period of time as the glacial deposits at the Nash mine.

DEPOSITS AND GORGES IN THE VALLEY OF THE SOUTH FORK OF SALMON RIVER.

About eight miles from the head of the South Fork of Salmon river, in Siskiyou county, there is the Thompson Bar

hydraulic mine, owned by the Salmon River Consolidated Gold Mining Company, of which Mr. William Cooper is superintendent, and hence the property is popularly known as "Cooper's mine." There is a distinct old channel separated from the present river channel by a "rim" of high bed-rock and occupied by well water worn river gravel, abounding in huge boulders of Courtney granite. This old channel and its contents differ not in any important particular from the present river bed. The river deposit passes upward into a somewhat different material in which local debris from the neighboring Crosby gulch plays an important part, and finally the latter excludes the granite boulders that are a distinguishing feature of the ordinary river deposits.

This upper formation is composed of hornblende schist and debris form the various dikes occurring in the basin of Crosby creek. The material is coarse and largely angular. Blocks three feet in diameter occur. There was a little wearing by stream action and no complete sorting of the material, yet the various pits of Cooper's mine show that it is everywhere distinctly and nearly horizontally stratified, probably by the action of the river. The thickness of the deposit is apparently from 150 to 250 feet.

It is an alluvial fan formed at the mouth of the Crosby gulch where the stream issued into the broader valley of the main river. It is traceable for one-half mile or more up the gulch and it is here evident that when completed its central line was somewhat higher than the sides, forcing the creek to one side and compelling it to cut a rock gorge on the border of the deposit. This, together with the angularity of the material and the large blocks included, demonstrate that it was not formed under ordinary stream conditions, but by torrential action, the rock debris loosely scattered about in the basin having suddenly been swept down and out of the gulch. This could not have come about through the sudden breaking of a lake barrier as Crosby gulch is extremely precipitous, rising on the southern face of a mountain reaching about 8000 feet above sea level, and within two miles descending to less than 4000 feet of altitude. Because of directly facing the sun, this side of the mountain has nowhere been glaciated. The only source of such a large body of water as is required to explain

the deposit at the mouth of the gulch must have been a cloud-burst.

Even at the present time, this particular mountain has a peculiar power to produce excessive precipitation. In August, 1901, there was a small cloud-burst on the western side of the peak, draining into Big Bend creek, which stream rose to a hight of ten or twelve feet, although its ordinary winter maximum is only two or three feet. All the tangle of the fallen trees in the bottom of the gulch was swept out and boulders three feet in diameter were easily moved.

The formation of the alluvial fan at the mouth of Crosby gulch rearranged the drainage. Crosby creek excavated a new cañon into very resistant hornblende schist. This is from 50 to 150 feet deep and very narrow. The river was lifted over 200 feet above its previous bed and forced to flow against the southern side of the valley. Then it cut a new cañon from 200 to 300 feet deep, encountering bed-rock and trenching into it from 50 to 100 feet.

For over one mile above Cooper's mine, the river flows in a narrow cañon. The precipitous rock wall on the south side terminates on a line about even with Cooper's flume on the north side of the valley, and above this line there is a gentler slope. Remnants of the old river deposit corresponding to the gravel in Cooper's mine are buried under the gentle slope and it is evident that the river has been displaced here also. In fact, a series of rather suddenly formed alluvial fans can be traced along the valley for several miles up the river and they have displaced the stream repeatedly. Each temporarily obstructed the valley and ponded the water behind the barrier. In these ponds the river deposited fine gravel without the coarse boulders of the older and the present bed.

Above the gorge the valley enlarges to a basin over a mile in length and several hundred yards in width. Some obstruction caused the accumulation in the bottom of the basin of several hundred feet in thickness of horizontally stratified fine gravel, alternating with layers of clayey silt of reddish color. The silt layers have some distinguishing characteristics. Silt layers of identical character occur in Cooper's mine in the lower part of the local alluvium, not very far above the old river channel. They seem to have been due to a condition

obtaining for miles along the valley and I consider them of the same age.

The fine gravel and silt in the basin have been mostly removed by erosion, but near the Couzetti hydraulic mine, there is a nearly perpendicular bank of them over 150 feet high. Resting on the fine, stratified, boulderless gravel there is a glacial moraine. This displays, where cut by the bank, a heterogeneous mixture of rock debris including granite boulders embedded in a sandy clay. It is piled up into a low ridge, the surface of which is encumbered with great granite erratics. A glacier came down a very steep gulch on the northern face of Mt. Courtney and upon entering the basin spread out and bent eastward or up the valley. The track of the glacier is very clear and there is no doubt but that the fine gravel deposit was laid down before the maximum extension of the ice. It follows that, if my correlation is correct, the alluvial fan at the mouth of Crosby gulch was formed at a time preceding the maximum extension of the neighboring glaciers. The difficulty of proving that no long time intervened between the completion of the fine gravel deposit in the basin and the glaciation of the basin is the weak point in the argument which I am trying to build up. However, there appears to have been no dissection of the fine gravel deposit before its glaciation. To bring about this dissection it was not necessary to cut through a rock barrier as the rock gorge down stream is entirely below the level of this fine gravel. All that was needed to bring about rapid dissection was the cutting through of the barrier of loose material at the lower end of the basin which must have been quickly effected. Not much rock cutting could have been accomplished in the gorge by the time the dissection of the fine gravel deposit was well advanced. Therefore, I believe that nearly the whole of the gorge cutting has postdated the maximum extension of the glaciers. The cloudburst to which is due the alluvial fan of Crosby creek seems to have occurred during the early stages of the glaciation. The increased moisture which caused the growth of the glaciers favored excessive precipitation in neighboring regions. The system of alluvial fans and associated fine gravels and silts was so clearly the product of a set of climatic conditions different from those which obtained for a long time and which

have obtained since, and the field evidence so clearly connects this short alluvial fan-forming period with the early stages of the glaciation that I feel that it is reasonable to assume one general cause for both in which a higher average humidity may have played an important part. We usually associate the idea of cloud-burst with that of desert conditions, but in the presence of evidence that in the early stages of glaciation in the Salmon river valley, there was suddenly formed by abnormal precipitation a series of alluvial fans which deranged the drainage, I will disregard all precedents.

The gorge above Cooper's mine is, if my interpretation is correct, the measure of the time since the early stages of the glaciers. It is about one mile in length. The depth near the lower end is about 300 feet of which probably 150 feet is the amount of rock cutting since the rearrangement of the drainage. Along the central portion of the gorge it is a "box cañon" (having nearly perpendicular walls) and trenched about 150 feet into the rock. Near the head it is in places but twenty to thirty feet wide and fifty to seventy-five feet deep. Here the river descends by a series of cascades, seventy-five feet in less than 300 feet of distance. The total descent of the river within the gorge is about 350 feet. The bottom of the cañon is nowhere much wider than the river. The southern side of an unclimbable rock wall almost from end to end. Over this there cascade in rainy weather streams from the mountain slope above.

Salmon river in passing the gorge contains the drainage of about twelve square miles. Late in summer it dwindles to several hundred miners' inches, but during the greater part of the year averages 10,000 inches. In several short flood periods each year it is a mighty torrent carrying probably many score thousands of miners' inches of water.

It is natural to suppose that a river of this character would erode its bed rapidly but in refutation of that idea I have the following evidence: The rock excavated is hornblende schist, one of the most resistant of formations. In this respect it will probably compare with any rock that I have seen post-glacially cañoned in the Mississippi basin—for instance, below Niagara and St. Anthony falls—as ten to one. The river is nearly all the year "as clear as crystal" and there is no fine sediment to

be continually grinding on the rock. The river bed is encumbered with huge granite boulders, some weighing hundreds of tons, and they are wedged into the narrow bottom of the gorge. Between and under the boulders are gravel and sand that protect the bed-rock from erosion. The wearing out of the boulders is an extremely slow process and their movement down stream is practically imperceptible. The river is incapable of moving them by impact, and progression is only effected by undermining and occasional rolling over. This occurs for an individual boulder at very rare intervals. I have watched the cañon for several years and have noticed no change in the groups of boulders; old settlers have noticed very little change in half a century. The placer miners have been accustomed to prop dams against groups of boulders and some of these dams have stood for many years. Portions of the river bed that were mined in 1852 are still identified by their original peculiarities. It is a mistake to lightly assert that because this is a mountain region and Salmon river falls 350 feet in a mile, erosion is here rapid. It is not. At the upper falls, about two miles farther up the river, nearly as large a stream has been dashing down over hornblende schist, descending probably 300 feet in an eighth of a mile, ever since the Salmon river glacier in its later stages beheaded the old Coffee creek, and yet it has accomplished an excavation that is very much less than that of the gorge under discussion. It is indisputable that the latter is much older than post-glacial time. Incorporating the factor of a larger flow of water during the later stages of the glaciation than at the present, we are still constrained to admit that the beginning of the gorge cutting was long anterior to the close of glaciation. To use the figures 2 or 3 in connection with this matter is too conservative.

This gorge is apparently large enough to have had its inception as far back as the Illinoian (Red Bluff?) epoch. But that is too radical a conclusion to entertain without question at this early stage of the study and instead I will tentatively connect its beginning with the Iowan epoch. At the same time I will not be positive that some factor which has entirely escaped my notice may not cause a final reference of the inception of the gorge cutting to the Early Wisconsin stage.

This gorge on Salmon river is directly comparable with the gorge below the Nash mine. It demonstrates that the maximum extension of the Union creek glacier occurred as far back as the maximum of glaciation on the Salmon river side. Being mutually corroborative they make out a pretty strong case that there are glacial deposits in this region much older than those which I have formerly described.

My observation of glaciation in the Sierra Nevada region was confined to the vicinity of the Yosemite valley. At the top of the Nevada falls I was impressed by the insignificant erosion accomplished by the Merced river since the striation of the granite. This point was, I believe, about twelve miles from the head of the Merced glacier and the striæ do not by any means represent the dying stages of the glacier. All the post-glacial rock cutting that I observed about the Yosemite valley is directly comparable with that accomplished at the upper falls of the South Fork of Salmon river. The glacial phenomena of the Sierra Nevada region, with the exception of those apparently older deposits described by Turner, date from the same glacial stage as the deposits on Union creek above the point which is one and one-half miles from its mouth, and above the moraine which crosses the valley of Coffee creek one and one-half miles from its head.

Is it not probable that the older glacial deposits and the associated rock gorges described in this paper represent a distinct stage of glaciation of a pre-Wisconsin age?

Berkeley, Calif., Jan. 19, 1903.

A NEWLY-FOUND METEORITE FROM MOUNT VERNON, CHRISTIAN COUNTY, KENTUCKY.

By George P. Merrill, Washington, D. C.

The National Museum has recently come into possession of a heretofore undescribed meteorite from the farm of Capt. S. T. Fruit, in Mount Vernon township, about seven miles northeast of Hopkinsville in Christian county, Kentucky. The meteorite, which is a pallasite, has been known for some thirty-five years by the occupant of the premises, where it served as a convenient stone on which to clean his boots after crossing the muddy fields. Although recognized as of a peculiar type

of stone, no suspicion of its meteoric nature was entertained, and it was only when the zinc and lead mining excitement of 1902 caused a sample of it to be sent to Mr. E. O. Ulrich of the U. S. Geological Survey, with a request for information, that its true nature became known. It is through the influence of Mr. Ulrich that the specimen was obtained for the National Museum.

Prolonged exposure has, naturally, brought about a great amount of oxidation to the exterior portion of the material. More than that, the rough usage to which the exposed portion was subjected and the breaking away of small masses by the curious and the prospector, has so obscured the original form that little of value on this subject can be said. The mass, as it came to the Museum, is in the form of a rude prism some 55 centimeters in hight, with sides measuring 33 centimeters and 36 centimeters, respectively. Although badly oxidized, two of the sides show rough pittings.

As stated above, the stone is a pallasite. It differs, however, from the usual pallasites in that, while those may properly be described as spongy masses of iron containing silicate minerals, this is really a mass of silicate with a cementing of iron, the proportion of iron, so far as can be determined from examination of the exterior of the mass, or of the small pieces which have been broken away, being much less than in the case of the pallasite of Kiowa county, Kansas. From the Admire pallasite, described by the present writer in the Proceedings of the U. S. National Museum for 1902, it differs in that the silicate (in this case olivine) occurs in large rounded blebs rather than in sharply angular fragments. In this respect also it differs from the Eagle Station, Kentucky, pallasite.

The mineral composition of this meteorite, so far as determined, has already been suggested. The main mass of the material is of olivine in rounded blebs and in sizes varying from five to twenty-five millimeters in diameter. These are quite closely compacted, with the usual nickel-iron alloy in the interstices, and serving as a binding constituent, and in smaller proportions the customary phosphide and sulphide.

Although the meteorite has not yet been fully investigated, it is of interest in bearing out certain observations by the writer in the case of the Admire, Kansas, meteorite, viz: the

olivines are often shattered, with thin plates—mere films or veinlets—of the phosphide extending up through them, as described in the paper already quoted.

A slab will be sawn from the entire length of one side of the mass for the purpose of showing its internal structure and securing material for study, the main mass being kept intact, after the usual custom of the Museum. It is expected that later more complete analyses will be made and a more detailed description given.

The weight of the mass as received was 351 pounds (159.21 kilograms). It will be known as the Mount Vernon meteorite.

THE MARL-LOESS OF THE LOWER WABASH VALLEY.*

By M. L. FULLER, Washington, D. C., and F. G. CLAPP, Boston, Mass.

A study of the marl of the lower portion of the valley of the Wabash river in southern Indiana and Illinois shows it to be the equivalent of the loess, replacing the latter over considerable areas. This marl-loess is usually a little coarser than the common loess and carries about 30% of $CaCO_3$, as compared with less than 5% in the common type. Numerous exposures have been discovered in which the materials are distinctly or even conspicuously stratified, and in some instances thin interbedded layers of fine gravel were noted. It is frequently abundantly fossiliferous, the forms being stated as a mixture of aquatic and land species. The stratified marl-loess appears to reach an altitude of about 500 feet or some 120 feet above the flood plain of the river. Instead of forming a mantle conforming to the surface inequalities, as is the case with the common loess, the marl-loess frequently occurs as extensive flats on broad gently sloping terraces at elevations ranging from 40 to 120 feet above the river. Beneath these there is usually buried a somewhat rugged topography. In distribution, the marl-loess is confined mainly to the east side of the valley, an occurrence which is most favorable to the hypothesis of wind origin, but the balance of evidence appears to be in favor of the view, with certain limitations, of aqueous origin.

*Abstract of a paper read at the late meeting, G. S. A., at Washington, D. C.

AMES KOB, NORTH HAVEN, MAINE; A SEASIDE NOTE.*

By BAILEY WILLIS, Washington, D. C.

Ames Knob is a mass of volcanic rock rising 106 feet above the sea, on the neck of land between the Fox Island thoroughfare and South Harbor, North Haven island, in Penobscot bay. Its petrographic character and geologic relations have been described by G. O. Smith, in his essay on the geology of the Fox islands, Maine. It is bounded on the north by a low plain cut on shales and limestones, of Niagara age, and its northern slope is a cliff resulting from the relatively great hardness of the igneous rock. The other slopes of the knob are of practically uniform rock, and variations in profile are attributable to conditions of attack, rather than of resistance. At an altitude of approximately 80 feet above the sea, on the southeastern and southern sides facing the Atlantic ocean, is a well-marked bench from which a steep facet rises to the summit of the knob. This bench, which has an average width of about 200 yards, is attributed to the action of waves cutting at rock level. The rocks in place exposed upon this bench and about its margin exhibit rounded glaciated profiles, but no longer bear striæ, so far as observed. Hence it is inferred that the date of submergence to this level preceded or was nearly coincident with the latest episode of glaciation, and that later influences have removed the minor evidences of ice action. Upon this glaciated bench there are now deposits of glacial gravel having the characteristic forms of spits and bars, which are accordingly attributed to wave and shore currents. These deposits indicate the presence of the sea at this level after the retreat of the ice.

The simplest explanation of the facts is that Ames Knob was submerged beneath the sea to a depth of 80 feet above the present sea level during and immediately after the latest glacial episode.

*Abstract of a paper read at the late meeting, G. S. A., at Washington, D. C.

ON THE MANLIUS FORMATION OF NEW YORK.*

By CHARLES SCHUCHERT, U. S. National Museum.

Introduction. In working out the very complete sequence of the Ontaric† and Lower Devonic rocks of Maryland recently published,‡ it became necessary to make detailed correlations with the New York series, the standard of comparison for the Paleozoic formations of the interior region of America. In this correlation the question arose as to the actual age of the formations of the Helderberg mountains immediately above the Hudson River formation, and particularly as to the proper position of the "Coralline limestone" of the Schoharie section. The fauna of the "Coralline limestone" holds a definite zone in the Appalachian region and its true position is proven in Maryland, where it holds a horizon far above the Niagaran with which Hall had correlated it. The first object of this article then, is to prove the actual position of the "Coralline

* Published by permission of the Secretary of the Smithsonian Institution.

†This and other terms are defined by Clarke and Schuchert, *Science*, n. s., X, 1899, pp. 874-878; and AM. GEOLOGIST, Vol. 25, pp. 114-119. To facilitate easy reference to the formations in the New York series, the following condensed table is presented with some emendations from the work cited:

Devonic	Mesodevonic	Erian	Hamilton	
			Marcellus	
		Ulsterian	Onondaga (Corniferous)	
			Schoharie	
	Paleodevonic	Oriskanian	Deerwville	
			Esopus (Caudagalli)	
			Oriskany	
			Kingston	
		Helderbergian	Becraft (Upper Pentamerus)	
			New Scotland (Delthyris)	
			Coeymans (Lower Pentamerus)	
Ontaric (Silurian or Up. Silurian)		Cayugan	Manlius	Manlius (Tentaculite)
				Rondout (Upper Waterlime)
				Cobleskill (Coralline li.)
			Salina	Bertie (Lower Waterlime)
				Salina proper
		Niagaran	Guelph	
			Lockport	
			Rochester	
			Clinton	
		Oswegan	Medina	
			Oneida and Shawangunk	

‡ On the Lower Devonic and Ontaric formations of Maryland. By C. SCHUCHERT. *Proc. U. S. Nat. Mus.*, xxvi, p. 413-424, Feb., 1903.

limestone" in the New York series. To do this, it will be necessary to give a number of sections on the east and west sides of the Helderberg mountains.

THE ORIGINAL CORALLINE LIMESTONE.

The Coralline limestone is described by Hall as follows:*

"In the neighborhood of Schoharie, and extending along the base of the Helderberg mountains and along the Hudson river, there is a thin mass of limestone, characterized by an immense number of corals, chiefly favosites, and which forms a band so distinct from any other limestone that it has been for many years known by this name. Besides the corals, it contains other fossils peculiar to it, and which in some localities are sufficiently characteristic in the absence of corals.

"In its western extension, this limestone can be traced as far as Herkimer county; but being only a few feet thick, its continuity further westward has not been ascertained in a satisfactory manner."

The position of the Coralline limestone is clearly indicated in the Schoharie section as worked out by Stevenson and stated beyond. This section in itself, however, does not locate the true position of the Coralline limestone in the generalized New York series.

The first attempt at correlating the "Coralline limestone" appears to have been by Hall in 1843.† He states "The *Catenipora* [=*Halysites*] is in a mass, which at Schoharie is known as the 'Coralline limestone,' and which is separated from the water-lime [of the Manlius] by twenty-five feet or more of a soft ash-colored rock destitute of fossils. This coralline limestone contains no fossils in common with the true waterlime above [=Rondout beds. This is an error as will be shown later]. It rests upon a green shale with iron pyrites, which, from the absence of the Medina sandstone and conglomerate, is succeeded below by the Hudson River group.

"The point to be decided is, whether the green shale, containing iron pyrites, is the representative of the Clinton, or of the Onondaga salt group. If the former, then the 'Coralline limestone' holds the place of the Niagara limestone, and must be considered its equivalent; but if the latter, then it is a part

* *Nat. Hist. N. Y. Pal.*, ii, 1852, p. 321.

† *Trans. Assoc. Amer. Geol. Nat.*, 1843, p. 292.

of the water-lime group. But in all instances which I have known, where the *Catenipora* occurs in the socalled water-lime group, there has been an extreme thinning out of the inferior groups, so that this one and the Hudson River group are brought within a short distance of each other."

The above quotation shows that the presence of *Halysites* had much to do in leading Hall to conclude that the "Coralline limestone" holds the horizon of the Niagara. In 1843, however, he does not make this correlation, but states that its true position in the time scale is dependent upon the age of "the green shale containing iron pyrites."

In 1852 Hall* makes a definite correlation with the Niagara limestone as follows:

"I believe it can be conclusively shown that this coralline limestone is no other than the Niagara limestone, and indeed representing the entire Niagara group. In the first place, it holds the same position, being above the Clinton group [the inference here being that Hall correlates the green pyritiferous shale of the Schoharie section with the Clinton; these shales, however, have yielded no fossils, and their age must be determined from other sections] and below the Onondaga-salt group." The latter is again assumption, since the "Waterlime" of the Schoharie section is supposed to be the thinned eastern edge of the Salina. This "Waterlime," however, lies above the Coralline limestone, contains its fauna, but not a single species of *Eurypterus* of the Waterlime farther west resting upon the Salina. Further, this "Waterlime" underlies the Tentaculite limestone or Manlius and should not be confused with the true Waterlime which underlies the Coralline limestone of Herkimer county. Hall was able to find the Niagara formation as far east as Oneida county "where it has become very thin, and contains but a few fossils. * * * Over a part of Oneida county and the western part of Herkimer, there is a space where no representative of the Niagara group has been traced continuously." No one has found a Niagaran fauna east of Herkimer county or in the Helderberg mountains. The Coralline limestone, however, has been traced from Herkimer county to the southwestern side of the Helderberg mountains, and in this region it is, as Hall states, "more close-

* *Nat. Hist. N. Y. Pal.*, ii, 1852, p. 321.

ly united perhaps with the drab limestone above," which he thinks is the Onondaga-salt group, but in reality it is the Rondout division of the Manlius.

Recently Dr. Clarke* has proposed the term *Cobleskill formation* to supplant the meaningless term Coralline limestone.

THE FAUNA OF THE CORALLINE LIMESTONE.

In looking over a typical collection of Coralline or Cobleskill limestone fossils, such as that of the American Museum of Natural History or of the Brooklyn Institute, one is impressed by the preponderance of the corals which make up the bulk of the fauna. While the species are few, yet the specimens of *Favosites* and *Stromatopora* are very common. The fauna discussed below is that of the original locality, Schoharie county, New York. Additional species from other places, of which many are at hand, will not be considered here.

Cyathophyllum hydraulicum Simpson.

Cyathophyllum hydraulicum Simpson MSS. Grabau. Bull. Geol. Soc. America, XI, 1900, p. 364, pl. 21, figs. 1a-1d.

Two specimens of this western New York coral are in the U. S. National Museum from Howe's cave near Schoharie (No. 10533). Upon them are growing *Favosites helderbergiae* var. *praecedens*, n. var.

Diphyphyllum coralliferum (Hall).

Diplophyllum coralliferum Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 322, pl. 72, figs. 1a-1c.

This species has not been seen in Herkimer county. Another closely related species is *D. integumentum* Barret from the Cobleskill of New Jersey.

Acervularia (?) inequalis (Hall).

Columnaria inequalis Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 323, pl. 72, figs. 3a, 3b, 4a-4c.

Acervularia communis Simpson, Trans. Amer. Phil. Soc., n. ser., XVI, 1889, p. 459 and text figures.

This characteristic fossil of the Cobleskill limestone has not been recorded west of Schoharie county, but it has also been found near Rondout, and in New Jersey, Pennsylvania, and Maryland. Specimens of this species never appear to be abundant.

* *Bull. N. Y. State Mus.*, 59, 1903, p. 42.

Favosites helderbergiæ præcedens, n. var.

Favosites niagarensis? Hall, Nat. Hist. N. Y. Pal., II. 1852. p. 324. pl. 73, figs. 1a-1e.

F. niagarensis is usually small and "spheroidal or irregular in form" in the Rochester shale, while *F. helderbergiæ* of the Coeymans limestone is often in "large, lenticular, depressed convex or hemispherical" masses. The Cobleskill specimens are spheroidal to lenticular colonies up to six or eight inches in diameter, and the other characters are also those of *F. helderbergiæ*, and not of *F. niagarensis*. Since the Cobleskill specimens never attain the size of the largest *F. helderbergiæ* (sometimes having a diameter of two feet in Albany county) to which they are related, it seems inadvisable to retain longer Hall's provisional identification. It may be known as *F. helderbergiæ præcedens*. The type specimens are in the U. S. National Museum (No. 10,533) and came from Howe's cave near Schoharie, N. Y.

This species is very abundant in the Cobleskill and is also found in the "Waterlime" or Rondout above. It also occurs plentifully about Litchfield, Herkimer county, N. Y., and in Pennsylvania, and Maryland.

Halysites c tenularia var.

Catenipora escharoides Hall, Nat. Hist. N. Y., Pal., II. 1852. p. 325.

Occurs in the cement rock at Schoharie and between the two cement horizons at Rondout. A similar form is found in the Cobleskill in Pennsylvania and Maryland. At times the species is very abundant.

Stromatopora constellata Hall.

in form" in the Rochester shale, while *F. helderbergiæ* of the pl. 72, figs. 2a, 2b.

Nicholson* in his valuable "Monograph of the British Stromatoporoids" did not elaborate this species. However, he remarks that, if *Coenostroma constellatum* Spencer is the same as Hall's species, then both are probably synonymous with *S. typica* Rosen. Since Spencer's material came from the Upper Niagaran (Upper Lockport) and Hall's from the Lower Manlius, it is not probable that both occurrences are of one species. Hall's name will be continued until the internal structure is determined.

* *Palæontographical Society*, London, 1886-1892, p. 173.

Stromatopora concentrica Hall.

Stromatopora concentrica Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 325, pl. 73, figs. 2-2b (not of Goldfuss).

Nicholson has shown* that *S. concentrica* Goldfuss, with which Hall identifies the Niagaran and Cobleskill specimens, is restricted to the Devonic of Europe. It has long been known that *S. concentrica* Hall means little or nothing and until the internal microscopic structure is worked out, these stromatoporoids have no stratigraphic nor biologic significance.

Orthothetes interstriatus (Hall).

Orthis interstriata Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 326, pl. 74, figs. 1a, 1b, 2a, 2b.

Streptorhynchus hydraulicum Whitfield, Annals N. Y. Acad. Sci., II, 1882, p. 193;—Ibidem, V, 1891, p. 508, pl. 5, figs. 1-3;—Geol. Ohio, VII, 1895, p. 410, pl. 1, figs. 1-3.

Orthothetes interstriatus Schuchert, Bull. U. S. Geol. Surv., 87, 1897, p. 297.

Orthothetes hydraulicus Grabau, Bull. Geol. Soc. Amer., XI, 1900, p. 365, pl. 22, figs. 1a.-1c.

This is one of the most widely dispersed species of the Cobleskill. It is also found about Litchfield, and Buffalo, New York, and in Maryland and Pennsylvania.

Stropheodonta (Leptostropha) bipartita (Hall).

Leptæna bipartita Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 326, pl. 74, figs. 4a, 4b, 5a.

Also occurs about Litchfield and in the cement beds (Rondout) at Schoharie, N. Y.

Stropheodonta (Leptostrophia) textilis (Hall).

Strophodonta textilis Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 327, pl. 74, figs. 6a-6d.

Chonetes jerseyensis Weller.

Chonetes jerseyensis Weller, Ann. Rep. Geol. Surv. N. J., for 1899, 1900, p. 8, foot-note.

This is a peculiarly marked species of *Chonetes*. The coarse striæ present their convex curvature to the cardinal margin and converge slightly in the medial part of the valves. Once seen, this shell is not easily confounded with any other species. There is but one other form of this kind in America, *C. macrostriata* Walcott, which, although described from the

* *Pal. Soc.*, London, 1886-1892, p. 2, 91, 164.

Middle Devonic, appears to be either from the Helderbergian or a somewhat lower horizon in the Eureka section of Nevada. *C. jerseyensis* was also collected in the Cobleskill at Schoharie by Gebhard and may be seen in the collection of the Brooklyn Institute. The writer found it on Wheelock's farm, Litchfield, Herkimer county, New York, near Selinsgrove, Pennsylvania, and Cumberland, Md. At all of these localities it occurs at a horizon about equivalent to the Cobleskill and appears to be the most constant and reliable indicator for this horizon.

Spirifer eriensis Grabau.

Spirifer sp., Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 327, pl. 74, figs. 8a-8d (specimens in Amer. Mus. Nat. Hist., No. 1771/4).

Spirifer eriensis Grabau, Bull. Geol. Soc. Amer., XI, 1900, p. 366, pl. 21, figs. 2a, 2b.

This shell from Herkimer county and Schoharie is very closely related to *S. modestus* of Maryland (this species is restricted to the Manlius), and it is a question whether the two forms are distinct. *S. modestus* may have a few more plications, but these as a rule are nearly obsolete, though fully twenty-five per cent of the specimens have them as strongly developed as in *S. eriensis*. It is found also in the "Waterlime" (Rondout) at Schoharie.

Spirifer modestus corallinensis (Grabau).

Spirifer crispus Hall (non Hisinger), Nat. Hist. N. Y., Pal., II, 1852, p. 328, pl. 74, figs. 9a-9h.

Spirifer crispus var. *corralinensis* Grabau, Bull. Geol. Soc. Amer., XI, 1900, p. 352 (the varietal name is improperly constructed).

This is not the Rochester shale *S. crispus* which has well developed plications and from which *S. vanuxemi* apparently descended. This Cobleskill species is almost devoid of plications and is closely related to *S. modestus* of the Maryland Manlius. The latter is always a larger shell and as a rule is more subquadrate, with a tendency to have distinct plications. It is also a common shell about Litchfield, Herkimer county, New York.

Whitfieldella (?) nucleolata (Hall).

Atrypa nucleolata Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 328, pl. 74, figs. 10a-10m.

Whitfieldella cf. rotundata Grabau, Bull. Geol. Soc. Amer., XI, 1900, 368, pl. 22, figs. 3a, 3b.

In Herkimer county this species is associated with *W.* (?) *sulcata.*

Whitfieldella (?) sulcata (Vanuxem).

Atrypa sulcata Vanuxem, Geol. N. Y., Rep. Third Dist., 1842, p. 112, fig. 5. — Hall, Ibidem, Fourth Dist., 1843, p. 142, fig. 5.

Merista bisulcata Hall, Nat. Hist. N. Y., Pal., III, 1859, p. 253 (error for Vanuxem's *A. sulcata*)

Whitfieldella sulcata Grabau, Bull. Geol. Soc. Amer., XI, 1900, p. 367, pl. 22, figs. 2a-2d.

This is a characteristic shell of the Cobleskill. It occurs commonly about Litchfield, New York.

Rhynchonella (?) lamellata (Hall).

Atrypa lamellata Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 329, pl. 74, figs. 11a-11h.

Also found in the "Waterlime" (Rondout) at Schoharie and in the Cobleskill about Litchfield, N. Y. This shell has an extended distribution in New Jersey, Pennsylvania, Maryland, and West Virginia. In New York it does not appear to pass far above the Cobleskill but in Maryland it ranges through 400 feet of the upper Salina and through 50 feet or more of the lower Manlius.







Rhynchonella (?) litchfieldensis n. sp.

Atrypa sp., Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 330, pl. 74, figs. 11i and 12.

This species is one of a group represented in the Rochester shales by *R. (?) neglecta* and in the Helderbergian by *R. (?) transversa.* It differs from the former in having more plications with the fold and sinus narrower and less pronounced. It is more closely related to *R. (?) transversa,* but never attains the size of this species, nor is the fold and sinus so broad. The figured specimen is from Wheelock's farm, Litchfield township, Herkimer county, New York, and is in the U. S. National Museum. (No. 34634.)

Tolmanites equiarmis Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 330, pl. 75, figs. 1a-1d.

This may be a *Dyticocrinus* or *Camptocrinus*.

Arcinites rotundus Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 331, pl. 75, fig. 3.

Looks more like an *Anthaxonia* than *Arcinites*.

Arcinites arcuatiformis Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 331, pl. 75, figs. 4, 5a, 5b.

This is not the shell of the same name again described as new by Hall in Nat. Hist. N. Y., Pal., III, p. 290, pl. 33, figs. 11-14. The Helderbergian species is now referred to *Arcinitopsis*.

Arcinites lunatiformis Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 332, pl. 75, figs. 6a, 6b.

Illionia sinuata Hall.

Avicula? sinuata Hall, Nat. Hist. N. Y., Pal., III, 1857, 1861, p. 265, pl. 8, figs. 7a-7f.

Hall states that his material came from the "base of the Lower Helderberg group, Winfield, Herkimer county." The writer found this shell in great abundance in the Cobleskill near the same place on Wheelock's farm, Litchfield, and this seems to be the only horizon for this species. The specimens are always found transverse to the bedding and standing on the posterior margin, indicating that *Illionia* is probably a burrowing bivalve. It will probably also be found at Schoharie.

Pleurotomaria subdepressa Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 332, pl. 76, figs. 2a, 2b.

May belong to *Ortonella*.

Murchisonia? ottara Hall, Ibidem, p. 333, pl. 76, fig. 3.

Murchisonia? tenebrosa Hall, Ibidem, p. 334, pl. 76, fig. 4.

Bellerophon aurora var. Hall, Ibidem, p. 334, pl. 76, fig. 7.

Bucania sp., Hall, Ibidem, p. 334, pl. 76, fig. 6.

This species appears to be very closely related to *B. profunda* of the Coeymans.

Trochoceras gebhardi Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 335, pl. 77, fig. 2; pl. 77*d*, figs. 1a-1d.—Grabau, Bull. Geol. Soc. Amer., XI, 1900, p. 371, pl. 21, figs. 3a-3b.

Trochoceras turbinatus Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 336, pl. 77, fig. 1.

Oncoceras expansum Hall, Ibidem, p. 337, pl. 77*d*, figs. 2a, 2b.

Looks like a fragment of a *Phragmoceras*.

Calceolaria convexa Hall, Ibidem, p. 337, pl. 78, figs. 1a-1f.

Better specimens of this species occur in the Manlius of Maryland. It is also found in Pennsylvania.

Lophospira cancellata (Hall) Hall and Clarke, Nat. Hist. N. Y., Pal., II, 1888, p. 87, pl. 19*b*, figs. 19-21.

Leperditia jonesi Hall.

Cytherina alta? Hall, Nat. Hist. N. Y., Pal., II, 1852, p. 338, pl. 78, figs. 2a-2d.

Leperditia jonesi Hall, Ibidem, III, 1859, 1861, p. 372. Also found in Herkimer County.

THE MANLIUS FORMATION OF VANUXEM.*

This formation was called by Vanuxem the "Waterlime group of Manlius." Subsequently this name was displaced by Tentaculite limestone and the term Manlius did not again come into use until 1899, when Clarke and Schuchert† revived it in accordance with the rules of priority and that a geologic formation shall take the geographic name of the place at which it was first studied. The typical section is at Manlius, Onondaga county, New York.

It is evident, from Vanuxem's description of the formation, that the term "Waterlime group" or rather the "Waterlime group of Manlius" was intended to cover all the waterlimes between the Salina and the Pentamerus limestone or Coeymans. The fossils figured or mentioned, however, are those of the Tentaculite limestone with one exception and do not include any of the *Eurypterus* fauna found in the lower waterlime of the same region. The formation, Vanuxem states, "consists generally of dark blue limestone, and usually of two layers of drab or water-limestone; the two always separated by an intervening mass of blue" (p. 110). "The line of separation between the water-lime group, and the Onondaga salt group [Salina], is rather well defined at the eastern end of the district. There a brownish impure limestone is seen, often mottled, containing columnariæ of a somewhat spherical form, and about the size of an inch or more; also a few encrinital fragments, and a small orthocera, the species not named. This is the mass which separates the two groups, and forms the base of the water-lime group" (p. 111).

The writer has not seen the type section of the Manlius and on application to the state paleontologist of New York, Dr. Clarke kindly furnished the following account of it.

"In the typical section in the hill east of Manlius village the blue limestones carrying *Spirifer vanuxemi*, *Tentaculites*

* *Nat. Hist. N. Y., Geol.*, part iii, Surv. Third Dist., 1842, pp. 110-116.

† *Science*, x, 1899, pp. 874-878.

gyracanthus, Leperditia alta, and some corals, are 150 feet thick. [This thickness probably also includes the Coeymans, which in this region is generally associated with the Manlius, the balance of the Helderbergian formations being absent here.] Over them lies just a trace of the Oriskany. Neighboring sections, which we have recently made at Brown's Falls, Chittenango Springs, at Waterville, and Oriskany Falls, show that below these layers carrying the fossils mentioned, lie dark-gray weathering waterlimes with *Eurypterus.*"

The fauna mentioned by Vanuxem (chiefly from the blue layers) are *Spirifer vanuxemi, Avicula rugosa, Tentaculites gyracanthus Holopea antiqua, Whitfieldella (?) sulcata,* (found only in the drab-colored beds or Cobleskill), and *Leperditia alta.* These species, excepting *W. (?) sulcata,* are from the upper portion of the Manlius or the Manlius *sensu-stricto.* From the lower portion he mentions *Columnaria globuliformis* (this species is not defined, but probably represents small globular specimens of *Favosites* which the writer regards as small colonies of *F. helderbergiae praecedens,* and *Halysites labyrinthica* ? (pp. 112-113).

While it appears that Vanuxem intended to embrace all the waterlimes of the Second Geological District of New York by the term Manlius, the fauna cited by him characterizes only the blue limestone and the upper waterlime beds, but not the lower waterlime having *Eurypterus.* Usage long ago fixed the lower Waterlime formation as characterized by *Eurypterus,* and it is therefore to be removed from Vanuxem's "Waterlime group of Manlius." The upper portion of the original Manlius is generally known as the Tentaculite limestone. However, after further field observations, the writer concludes that the term Manlius should embrace all the zones between the *Eurypterus*-bearing waterlime, or Bertie formation, and the Coeymans limestone. This is also in harmony with the intended limits of the Manlius as given by Clarke and Schuchert, 1899. According to this limitation then, the Cobleskill will fall into the Manlius as its lower member, since it underlies immediately the Rondout waterlime and above the *Eurypterus*-bearing waterlime or Bertie formation.

THE BERTIE FORMATION OF CHAPMAN.

Clarke and Schuchert* in proposing the term Rondout, intended to apply this name to the "Waterlime" formation characterized by an abundance of *Eurypterus*. It now turns out that the formation at the type locality, Rondout, N. Y., is younger and lies above the Cobleskill member of the Manlius and it has therefore lost its intended significance (see Rondout section). For the lower Waterlimes so characteristic about Litchfield and situated beneath the Cobleskill zone of the Manlius, and again the same formation about Buffalo, New York, beneath the "Bullhead rock" and above the Salina, it is proposed to use hereafter the name Bertie formation, proposed by Chapman in 1864.

In giving the distribution of the "Lower Helderberg group" in Canada, Chapman† defines the Bertie formation as follows:

The Lower Helderberg group "thins out towards the west, and presents merely two or three outlying patches in the neighbourhood of Montreal [= Becraft], and a comparatively narrow strip of slight thickness in Western Canada, between the eastern end of Lake Erie and the township of Cayuga. * * * This strip, in no place exceeding fifty feet in thickness, consists of the lowest division of the group as subdivided by the New York geologists, or of the equivalents of their 'Waterlime group.' With us, in Western Canada, it might be called the 'Bertie or Cayuga dolomite,' as its only known exposures are in those townships; or a still better term would be the *Eurypterus* formation, so named from its principal and characteristic fossil. * * * In the above townships its strata consist of thin-bedded greyish dolomites, interstratified towards the base with a few brownish shales, and with a brecciated bed composed chiefly of dolomite fragments."

Bertie, Ontario, is but five or six miles west of Buffalo, New York, and the water-lime of the former place is the direct continuation of the last named region. It is therefore certain that Chapman gave the name Bertie formation to the Waterlime beds of western New York characterized by an abundance of *Eurypterus*. This formation about Buffalo is

* *Science*, Dec., 1899, pp. 874-878.

† A popular and practical exposition of the Minerals and Geology of Canada. By E. J. CHAPMAN, Toronto, 1864, p. 190.

more fully described by Grabau* under the term "Rondout waterlime." From this description we learn that the Bertie formation is about fifty feet thick and consists of magnesian limestones and shales, grading downward into the Salina gypsiferous shales, the latter having here a thickness of about 380 feet Above the Bertie cement rock and not sharply separated from it, is the Manlius limestone, locally known as the "Bullhead rock." It is seven to eight feet thick and is a mottled dolomitic compact semicrystalline limestone "having frequently the appearance of a limestone breccia." The fauna of the "Bullhead rock" described by Grabau† is unmistakably that of the Lower Manlius, or the Cobleskill member. Upon the Manlius of this region there was deposited a part of the Upper Oriskany, but nearly all of it was removed by erosion before the introduction of the Onondaga limestone. Parts of this sandstone are still preserved in the joints and cavities of the Lower Manlius. Unconformably upon the Manlius rests the Onondaga cherty limestone abounding in corals of Middle Devonic age.

In the southern half of the Appalachian region, the Bertie formation is not lithologically distinguishable from the Salina, and here the latter term is extended to embrace the entire interval between the Niagara and Manlius.

HELDERBERGIAN SECTIONS.‡

Section at Indian Ladder, Albany County, N. Y.

Marcellus, Onondaga limestone, 85 ft. Schoharie grit, 3 ft. Esopus shale, 100 to 120 ft. Upper Oriskany, 1 ft. Hiatus. New Scotland and Becraft, 160 ft. Coeymans, 52 ft.

Manlius, 50 ft.

Transitional Manlius (14′ 6″). Has no *T. gyracanthus* but *Spirifer vanuxemi* occurs throughout.

Thin bedded Manlius (31′ 6″). Has an abundance of *T. gyracanthus, S. vanuxemi, Leperditia alta,* etc.

Waterlime or Rondout (4′ 6″) resting unconformably on the Frankfort shales of the Champlainic.

Not far away to the north, at Altamont, on the Frankfort rest dark-gray, thin-bedded limestones less than 2 ft. thick. These

* *Bull. N. Y. State Mus.*, ix, No. 45, 1901, pp. 115-117.

† *Bull. Geol. Soc. Amer.*, xi, 1900, p. 350.

‡ These sections and many more extending from Pennsylvania south to Tennessee will be published elsewhere in greater detail and will be the basis for a general discussion of the sequence of events in the Cumberland Mediterranean throughout Ontaric and Devonic time. This work is now nearly completed.

resemble the upper layers of the "Waterlime" (Rondout) at Schoharie and Howe's cave, to which formation they are referred by Prosser. There is here, therefore, very little of the cement rock of the Rondout member, none of the Cobleskill limestone or the so-called Clinton of the Schoharie section. To the south of Indian Ladder, at New Salem, the Manlius (s.s.) has a thickness of 45 ft., the Rondout 6.6 ft., followed by 10 inches of greenish sandstone to coarse arenaceous shale. The latter layer Prosser regards as possibly representing the Clinton. It is more properly regarded as the invading basal deposits of the Rondout as it unconformably overlies the Frankfort shales of Champlainic time.

Becraft Mt., near Hudson, New York.

Onondaga, 15 to 20 feet. Esopus and Schoharie, 200 feet. Upper Oriskany, about 2 ft. Short hiatus here. Kingston, about 20 to 25 feet. Becraft, 40 feet. New Scotland, 75 feet. Coeymans, 45 feet.

Manlius (including a part of the Rondout), 57 feet.

Upturned Normanskill shale (Champlainic).

Schoharie, New York.

Marcellus. Onondaga, 49 feet. Schoharie, 12 feet. Esopus, 130 feet. Upper Oriskany, 10 to 20 feet. Hiatus. Becraft, 30 feet. New Scotland, 85 to 95 feet. Coeymans, 65 feet.

Manlius (sensu stricto), 45 feet. Entire Manlius, 92 ft. Rondout member or Waterlime series, 39 ft. "The passage to the Manlius above was quite as gradual as that from the Coralline" (Stevenson). In the Gebhard collection of the Brooklyn Institute are shown fossils from this Waterlime that are of the Cobleskill fauna. These are small globular *Favosites*, probably small colonies of *F. helderbergiae* var. *praecedens*, *Hedcrella* or *Reptaria*, *Stropheodonta bipartita*, *Rhynchonella* (?) *lamellosa* and *Spirifer eriensis*.

Cobleskill limestone, 7 feet. It is from this zone that Gebhard derived the Coralline fauna described by Hall in Nat. Hist. New York, Pal., II, 1852. pp. 321-338, and listed above.

Unfossiliferous shales weathering dirty-white, with much nodular pyrite and barite. This horizon is generally but erroneously correlated with the Clinton. To the south of Gebhard creek bridge, Prosser gives the thickness as 19 feet, while at Howe's cave the thickness is 24 to 40 feet. On the basis of the adjoining sections, the age of these olive green shales seems to be Lower Cobleskill. The sea transgressed from the south because in that direction more and more of the Manlius and all of the Salina strata are present. To the northward and eastward not only the Salina but the lower portion of the Manlius as well, gradually disappear.

Litchfield township, Herkimer Co., N. Y.

Onondaga. Covered slope, 15 ft. Coeymans, 80 ft.

Manlius about 110 feet.

The upper 80 feet not well exposed, but parts can be seen in various places.

Cobleskill member, 30 feet.

Thin, irregular bedded gray to yellowish impure limestone abounding in the fossils of the Coralline limestone. Many of the species from this place are noted in the fauna listed above.

Bertie formation. From the Cobleskill member down to the *Eurypterus* beds the steep hillside for 60 feet does not expose the strata. The writer is uncertain whether the strata of this zone should be added to the Manlius or the Bertie. They are probably more correctly referred to the latter.

Waterlime, or the "drab colored layers of the Onondaga salt group." Near the top occur *Eurypterus remipes, Pterygotus macropthalmus, Dolichopterus macrochirus, Pseudoniscus roosevelti*, etc. Niagara absent. Clinton thinning from 200 feet in the west to 50 feet in the east. Medina absent. Oneida thin, resting on the Frankfort of the Champlainic.

Vicinity of Rondout, Ulster County, N. Y.

Onondaga averaging for Ulster county 60 feet. Esopus 200 to 300 feet. Oriskany 30 feet. Kingston and Becraft about 40 feet. New Scotland 60 to 70 feet. Coeymans 30 to 60 feet.

Manlius 77 feet.

Ribbon limestone (6′ to 8″) at top, then *Stromatopora* limestone (8′). *Tentaculite* limestone (14′), and the cement beds (40 feet).

Cobleskill limestone 7 feet. Abounds in the corals of this formation. One mile north of East Kingston this member has thinned to five inches (Darton). Farther north it is unknown. Upturned Hudson River slates.

Port Jervis, New York.

Beneath the Helderbergian occur the following formations:

Manlius, 126 feet.

Spirifer vanuxemi zone 22 feet. Waterlime abounding in *Ostracoda* and *Stromatopora*, 56 feet. Coralline limestone with *Acervularia* (?) *inequalis, Halysites, catenularia* var., *Favosites helderbergiae* var. *praecedens, Diphyphyllum integumentum, Stropheodonta hipartita, Orthothetes interstriatus, Rhynchonella* (?) *lamellata, Whitfieldella nucleolata, Calymene camerata*, etc.

Thin bedded limestones and shales, 42 feet. The diagnostic fossil of the lower half is *Chonetes jerseyensis*, otherwise the fauna is that of the Cobleskill member minus its corals.

Salina. Bossardville limestone (12′) at top and Poxima Island shale (1′) below. Both members thicken rapidly southwestward.
Unconformity here as there is no Clinton nor Niagara.
Medina red shale above passing into the Shawangunk grit, 750 feet.
Hudson River slates upturned and eroded.

POSITION OF THE CORALLINE LIMESTONE.

The actual position of the Coralline or Cobleskill limestone is located in the Schoharie section (see p. 173). Here it is a zone seven feet thick, resting on unfossiliferous pyritiferous shales, the exact age of which cannot be determined at Schoharie, but is as stated usually regarded as the eastern attenuated edge of the Clinton. The Niagaran is not present here, and Hall states that it has thinned out to a thin concretionary band in Herkimer county and is absent east of this region.* Yet Hall believed the Cobleskill to be the eastern representative of the Niagara. Above the Cobleskill in the Schoharie section follows a Waterlime (not the Waterlime or Bertie formation of Litchfield but the Rondout member), which differs in color from it, but this expression of a change in the physical conditions did not affect the fauna, since the most abundant coral *Favosites helderbergiae praecedens* continues into the Waterlime for three feet. Not only this, but three characteristic species of the Cobleskill, *Strophcodonta bipartita, Rhynchonella (?) lamellata,* and *Spirifer eriensis,* continue still higher in the same section. These facts show that the Cobleskill limestone is intimately connected with the "waterlime" or Rondout of the Schoharie section and also that the latter is but an early phase of the Tentaculite limestone, because it has two of its characterizing fossils, as *Spirifer vanuxemi* and *Leperditia alta.* The Waterlime about Litchfield, to which the name Bertie formation is now applied underlies the Cobleskill, and has a fauna the equivalent of that of the cement beds in the quarries at Buffalo, New York. Not a single species of the eurypteroid fauna of the Bertie limestone has been discovered in the Waterlime above the Cobleskill.

Passing to the east of Schoharie and observing the sections of Albany county, one sees that the unfossiliferous pyritiferous shales are absent, and further, that in the Indian Ladder sec-

* *Nat. Hist N. Y., Pal.*, ii. 1852, pp. 106-107.

tion the Rondout is reduced to four and one-half feet, but which at Schoharie has a thickness of thirty-nine feet.

To the west of Schoharie, about Litchfield, Herkimer county, the Manlius including the Rondout and Cobleskill members, has a thickness of 110 feet, beneath which is a covered slope of about sixty feet to the true Waterlime or Bertie formation with the Eurypterus fauna. In other words, the overlapping of the successive younger formations is from the west and south to the east and north. In Herkimer county the Clinton is not followed by the Niagaran, but at once by the Salina. Farther east the Clinton also fails, and at Schoharie, after nineteen feet of the pyritiferous shales, there follow at once the Cobleskill, the Rondout, with the Coralline fauna, the Upper Manlius, and then the Helderbergian. Here the united thickness of the Cobleskill, Rondout and Upper Manlius is ninety-one feet, while about Litchfield the same zones are 110 feet thick. Therefore, the pyritiferous shale of Schoharie cannot be the Clinton, but probably is the thinned eastern edge of the lower part of the Cobleskill of the Litchfield section and not of the true Waterlime or Bertie formation.

From a faunal standpoint the Cobleskill shows clearly that it cannot be the eastern representative of the western Niagara. There is not a species common to the two formations. This fact was noticed by Hall in 1852—though less emphatic—when he described the fauna, since he distinctly queried all the supposed specific identities. The presence of *Halysites* had some influence in this correlation, but certainly this genus alone cannot make this fauna Niagaran, since it is known to range from the Black River upward into the Manlius.

An analysis of the Cobleskill fauna also shows it to be younger and more advanced than that of the Niagara and also that it is not a direct development out of the latter. The diagnostic Niagaran types are not present in the Cobleskill fauna, while the latter is clearly the precursor of that of the Tentaculite limestone. This view is further sustained by the species in common (four out of thirty-one) to both horizons.

Tracing the Cobleskill and Manlius faunas southward, the writer has noticed that both are very persistent throughout New Jersey, Pennsylvania, into Maryland and West Virginia. In the same direction it has also been seen that the Ontaric

sequence is completed, that some of the formations increase in thickness, and that all lie conformably beneath the Helderbergian.*

In southeastern New York the Manlius is about the thickness of that in Herkimer county, but here the Cobleskill appears to occur about thirty feet higher than to the north. At Grovania and Selinsgrove Junction, Pennsylvania, the Cobleskill fauna occurs at about the same horizon as in southeastern New York. Farther south in Pennsylvania and Maryland it is more diffuse and ranges through a horizon of about fifty feet, if one is to judge by the position of the corals in the local sections of the Manlius. *Rhynchonella (?) lamellata* is not reliable as an indicator of the Cobleskill fauna, since in Maryland it is known to range through 450 feet of strata of the Upper Salina and Manlius formations.

THE MANLIUS FORMATION REDEFINED.

In the preceding pages it has been shown that the Cobleskill limestone is not the eastern representative of the Niagaran of the western part of New York, but that it is inseparably connected with the Rondout member of the Manlius, and that this zone follows without break into the Tentaculite limestone. The latter is usually regarded as the entire Manlius formation, but it will be more expressive of conditions in nature to extend it to embrace all the strata between the Bertie and Coeymans limestones. This will also be more in harmony with Vanuxem's conclusion, since he included the horizon having the Cobleskill fauna in his Manlius formation (see pages 169, 170). From his definition of this formation, usage long ago excluded the lower Waterlime, and this part is here referred to as the Bertie limestone. Therefore, the Manlius formation, as above defined, includes in the typical area, Herkimer and Schoharie counties, N. Y., the Coralline or Cobleskill limestone, the Upper "Waterlime" or Rondout and the Tentaculite limestone or Upper Manlius.

At present, the recorded fauna of the Manlius is a small one. In the near future, however, the writer hopes to describe a large accession made in Pennsylvania, Maryland, and West

* For proof of this in Maryland see Schuchert "On the Lower Devonic and Ontaric formations of Maryland, (*Proc. U. S. Nat. Mus.*, xxvi, 1903, pp. 413-424).

Virginia. A striking addition comprises many new species of cystids and crinoids. Of *Sphaerocystites multifasciatus* several thousand specimens are at hand, and of *Camarocrinus* many hundred individuals, some of which have a diameter of five inches. Bryozoa and ostracods are other characteristic elements of the Manlius, and its fauna is Siluric in facies. Out of this fauna some of the Helderbergian life developed, but the latter fauna also received many new immigrants towards the close of the Coeymans. It is these two elements, both derived from the North Atlantic, that together make up the Helderbergian fauna.

Thickness of Manlius. Along the eastern side of the Helderberg mountains and east of the Hudson river at Becrafts mountain, the Manlius is not fully developed (50-57 ft.), and these younger deposits were laid down after the Cobleskill fauna had invaded southeastern New York. Along the western side of the Helderbergs about Schoharie there is a far better development (91 feet), and the full series is seen in Litchfield township (110 feet). At Port Jervis, New York, the thickness is 126 feet, and throughout Pennsylvania, Maryland and West Virginia it varies between 100 and 145 feet. This variation, however, is probably due somewhat to interpretation, since, in a continuous series of like deposits correlated over a wide area, the faunal occurrences cannot be depended upon to hold the same plane throughout. In a general way, the average thickness for the Manlius may be taken as 110 feet.

EDITORIAL COMMENT.

A NEW BUILDING FOR THE NATIONAL MUSEUM AT WASHINGTON.

Among the bills passed during the closing hours of the recent Congress was one providing for a new building for the U. S. National Museum, a matter in which, it is reasonable to suppose, the readers of this journal will have more than a passing interest.

The present National Museum building, as is well known, is a cheap affair, costing only about $250,000, erected in 1881 to meet the emergencies of the acquisition of large collections from the Centennial Exposition in 1876. It was long ago ap-

parent that this building was not only too small, but otherwise unsuitable for museum purposes, as well as entirely lacking in dignity. For several years the matter of a new building has been under consideration, but for one reason or another the plans have never matured. The one for which provision is now made, as shown by the tentative plans, is a rectangular granite building, having a frontage of about 486 feet, a depth of 345 feet, and a hight above the ground in front of about 70 feet, with two open courts. As designed, the building has four floors, inclusive of a basement, and will afford about 400,000 square feet of floor space. The first and second floors are intended for the public exhibition collections and the basement and upper floor for the reserve or record collections, work rooms, offices, and other miscellaneous purposes.

The interior arrangement above the basement is a combination of large and small halls, the three largest halls being lighted from above and having two series of galleries of sufficient width to permit of their being screened off and made into series of separate rooms for exhibition and other purposes. This arrangement has been adopted as practically furnishing the largest possible amount of well-lighted floor space in a building of the size proposed and as presenting many other important advantages.

The limit placed by Congress upon the cost of the building is three and one-half million dollars. While the space provided is not all that was desired, it will, at least in connection with the present building, give room for expansion for several years to come. As may be recalled in our editorial comment on the Department of Geology in the National Museum, in the August, 1901, number of this journal, it was estimated that the Department of Geology alone will require about 100,000 square feet of space during the next ten years. Should this estimate prove to be correct, the accommodations afforded this department in the new building will not be more than sufficient for the next twenty-five years.

In consideration of the many cheap expedients to which the Government has resorted during years past, the scientific community is certainly to be congratulated on the satisfactory outcome of the work of the Museum authorities during several years past. G. P. M.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Alphabetical cross-reference catalogue of all the publications of Edward Drinker Cope, from 1859 till his death in 1897. PERSIFOR FRAZER. (Mem. Revista, Soc. Cien., Antonio Alzate, 1899-1900. Mexico.

All paleontologists and other naturalists who study the work of Cope will be pleased to have this thorough catalogue. By it any paper of Cope may be found without delay. Dr. Frazer has rendered a great service to the memory of Cope as well as to future generations that will desire to know of his writings. N. H. W.

Recent Geologic work in Franklin and St. Lawrence counties [New York]. H. P. CUSHING.. (20th report of the State Geologist, 1900, reprinted from the 54th annual report of the New York state museum. pp. 123-182, Albany, 1902.)

Prof. Cushing is carrying on a series of careful diagnostic distinctions in the Adirondacks, based largely on field observations in the areas of gneiss, granite and anorthosyte. He is approaching some conclusions on topics which are of fundamental importance in Archean geology. His latest results are summarized as follows, by himself:

"The above recorded observations seem to the writer to prove in some cases, and to strongly indicate in others:

1. That the Adirondack anorthosyte is cut intrusively by an augite syenite which is therefore younger.

2. That while the larger part of the augite-syenite of the Adirondacks is in such situation in respect to the anorthosyte as to render impossible any determination of relative age, its general character is so uniform throughout that it is exceedingly probable that it is all of the same approximate age, and consists of intrusions from this same source.

3. That at their borders these syenites pass over into granite, part of which at least cut the syenite eruptively and are therefore younger.

4. That the syenite grades into granite on the one hand and into gabbro-dioryte on the other, and apparently into anorthosyte as well.

5. That the three together, anorthosyte, syenite, and granite, form a great eruptive complex in the heart of the Adirondack region, and that all are younger than the (in part at least) sedimentary Grenville rocks.

The writer was at first disposed to take a different view from that given above, thinking that the probable explanation of the phenomena was the presence of augite-syenite of two different ages in the region, the one younger and the other older than the anorthosyte, the last to be classed in the general gneiss series of the Adirondacks. While that may yet prove the true explanation, the probabilities seem to favor the one outlined above."

Mr. Cushing gives very pertinent remarks on the classification of the Adirondack pre-Cambrian rocks, and on the relationship of the syenite and granite to the anorthosyte. N. H. W.

Les analyses en bloc et leur interpretation, par M. F. Fouqué. (Bull. Soc. Fr. Mineral, 1902, XXV., pp. 278-359).

In attempting a review of this important work it has seemed that a few quotations will best serve the purpose.

"Block-analyses of eruptive rocks have found great favor of late years among petrographers." * * *

"When a rock is holocrystalline, and when one has made separately and beforehand an analysis of each one of the constituent minerals it is possible to deduce from the block-analysis the quantitative mineralogical composition, a fact, evidently, of some importance. But if the condition named is not fulfilled it must be admitted that only controvertible results are obtained even when the microscope has revealed the nature of the constituents of the mineral mixture studied." * * *

"There are few holocrystalline rocks which do not belong to the category of rocks called plutonic, which are characterized for the most part by the presence of crystals that are rarely encountered among the mineral substances derived from the action of volcanoes of the present time. Volcanic rocks are formed essentially by means of igneous fusion. The minerals of the plutonic rocks are intimately related, on the contrary, to products crystallized in veins by the aqueous method." * * *

"In plutonic rocks the frequence and sometimes even the pronounced predominance of quartz, muscovite, tourmaline, fluorite, etc., exclude the idea of a production directly from a molten magna and show that nature has here availed herself chiefly and sometimes solely of a *modus operandi* entirely different. If the rocks in question emanate primordially from a fused silicate magma in the midst of which their elements have temporarily existed under the influence of pressure, they are now only indirectly connected with this magma; they have been, as it were, extracted from it and transported a greater or less distance by the action of mineralisers; they have thus lost the imprint of their first home, and acquired characters essentially different from those possessed by their original matrix. They are as far removed from it as the products of volatilisation, of decantation or of crystallisation from an aqueous solution can be from their primitive host." * * * Therefore, chemical analyses of these rocks "have no value so far as their origin is concerned."

These considerations "do not apply to the study of rocks called volcanic. These form before our eyes in nature, we see them derived directly from igneous fusion, and we can easily reproduce in our laboratories most of them by fusion of their chemical elements and properly controlled resolidification. The connection between the solid rock and the fused magma from which it is derived can be followed step by step. Modifications produced by crystallization hardly change the composition at all."

The author then proceeds to a detailed study of a large number of mass analyses of the volcanic rocks of Santorin with especial reference to the composition of the feldspar as derived from the composition of the rock. He shows that there are two chief varieties of volcanic rocks

at Santorin which Becke has called santorinyte and alboranyte. He then proceeds to a similar study of certain volcanic rocks of Auvergne. Probably the most important part of the article is comprised under the caption:— "Critical examination of the theory of differentiation." The author states that this theory includes the following hypotheses:—

"1. The terrestrial globe must have been primitively fused in all parts, and homogeneous."

"2. The present heterogeneity of eruptive products must be due to spontaneous separations which have occurred in the original magma under the influence of inequalities of temperature."

"3. Differentiation is still in progress and has continued constantly since the beginning of geological time. The general molten magma has divided more and more, and the partial magmas, obeying the same law, have divided in their turn into magmas of the second, and third order, etc., Thus differentiation is a normal phenomenon, subject to fixed rules, which circumscribe the process more and more as nature pursues its subterranean work."

Certain objections to these hypotheses are then stated.

"In the first place, nothing demonstrates the primordial homogeneity of the earth. If such a state had ever existed it would have been due either to the uniformity of composition and distribution in space of the cosmic materials whose precipitation and agglomeration have given rise to our globe, or to an energetic and prolonged mixing of the fused magma in the earliest period of the genesis of the earth as a distinct planet. Now, neither of these explanations can be accepted. The diversity of composition of the meteorites falling in our own times shows clearly that the cosmic material still in circulation in space is wholly lacking in homogeneity; furthermore, the study of the results of spectral analysis of the stars confirms this conclusion." * * *

"As for the explanation of the primordial homogeneity by means of a supposed mixing and of the extreme fluidity of the primordial elements of the globe, no facts support it; it is a purely gratuitous hypothesis, and even in contradiction with what the laws of physics, mechanics and astronomy have led us to believe as to the destiny and rigidity of the central parts of the earth, and with what is known concerning the viscosity of the fused material beneath the crust of the globe. The hypothesis of a single homogeneous primitive magma (the Urerdmagma of the German and Scandinavian petrographers) therefore ought to be entirely abandoned."

The author then points out that crystallisation in a fused silicate magma produces only a differentiation of a character essentially mineralogical, and not geological. And further, that while varying specific gravities would tend to separate crystals in a magma, the heavier crystals can not descend much below their initial position without being redissolved on account of the higher temperature encountered. Therefore this process can only produce a small vertical transfer of materials.

The theory that differentiation can be produced by the earlier crystallisation of the more basic minerals on the cooler walls of a fused

magma is considered to need confirmation. In any event this theory can evidently not be appealed to as explaining differentiation in a tangential direction on the earth's surface.

As to the theory of more general application that any given magma will differentiate while remaining in the liquid state into two or more magmas of varying composition, the reader is referred to Becker's classic articles,* which present serious objections based on careful experimentation. The author then presents objections of a more general character, but lack of space forbids following the argument further. It may be well, however, to quote the conclusions reached:—

"1. The heterogeneity of the globe is primordial both in the tangential and radial direction; it has not undergone very considerable modification during geological time. Crystallisation and the slow and limited movements caused by the difference in density between crystals and magmas containing them are the only efficient causes of sensible displacements" of materials in magmas.

"2. The theory of differentiation taken in its full extension, with the meaning that modern petrographers have attributed to it, meets with grave objections, not to say impossibilities."

"3. It is either based upon conceptions entirely gratuitous, or the facts of detail cited in its support are uncertain or susceptible of other interpretations which are more probably correct." A. N. W.

Les Roches Alcalines caracterisant la Province Petrographique d' Ampasindava, par A. LACROIX. (Nouvelles Archives du Museum d'-Histoire Naturelle, 4th Series, Vol. I. 4to, 214 pages, 10 plates and 45 figures, Paris, 1902.)

The first two chapters of this memoir, embracing all the descriptive matter, were briefly reviewed in the November number of the GEOLOGIST (Vol. XXX, p. 328). The third and final chapter (second fascicule) has now appeared; it is devoted to a summary statement of results, and a discussion of the conclusions of general interest to be drawn from the study—as previously stated the subject of the memoir is a new petrographic province situated in the northwestern part of Madagascar—this province is characterized by the abundance of eruptive rocks which are of many types, representing all the alkaline rock families now known. In known geographic area the province includes only a small fraction of the total area of Madagascar covering nearly the whole of the extreme northern end. However, Lecroix suggests that this may be merely an outlier of a possible petrographic province of immense size and similar characteristics extending all the way from the Transvaal along the eastern coast of Africa through Zanzibar, British and German East Africa, and Somaliland, across the Red sea to Yemen in Arabia.

The following table is a summary of the author's conclusions in the most condensed form possible. It is impossible in a brief review of this character even to enumerate the reasons given by the author

* *Am. Jour. Sci.*, 1897, iii, p. 21; iv, 257.

for rejecting the term teschenyte and greatly restricting the signification of the name theralyte, as well as for other features seen in the table.

NON-QUARTZOSE ALKALINE ROCKS.

FAMILY NAME	LEUCOCRATIC MINERALS	LEUCOCRATIC GROUP	MESOCRATIC GROUP	MELANOCRATIC GROUP
Alkaline syenyte	Orthoclase (Anorthoclase, etc.)	Pulaskyte Sanadinyte	Laurvikyte	Shonkinyte malignyte
Monzonyte	Orthoclase Plagioclase	Lencocratic monzonyte	Normal monzonyte	Olivine monzonyte (kentallenyte)
Feldspathoid syenyte	Orthoclase Nepheline, etc.	Normal nepheline syenyte (ditroyte, fayayte) Nosean sanadinyte	Covyte	Theralyte
Feldspathoid Monzonyte	Orthoclase Plagioclase Nepheline	Sodalite microtinyte	Normal nepheline monzonyte (essexyte)	Melanocratic essexyte and sommayte
Feldspathoid gabbro	Plagioclase Nepheline			Nepheline gabbro, Hauyne gabbro
Ijolyte and Missouryte	Nepheline	Urtyte*	Natronsussexyte*	Ijolyte and Missouryte
Alkaline gabbro	Plagioclase		Mesocratic dioryte-gabbro	Dioryte-gabbro

* See page 194 of memoir. A. N. W.

Index Animalium. C. D. SHERBORN, Cambridge, 1902, pp. 1195.

This is the first section of a work which in its undertaking is a monumental enterprise, and which, if completed, will be truly a wonderful achievement. The effort contemplates the cataloguing of all animal names, whether of fossil or living, that have been applied by naturalists. This volume contains the record from 1758 to 1800, and hence embraces but very few fossil names. The rest of the record will cover, if brought up to date, more than 100 years, and it is quite certain, considering the greater number and the greater industry of name-makes during the last century, to far exceed the present volume—and it will probably more than double the names contained in this volume.

This work has been in progress since July 1, 1890. It has been countenanced by the British Association for the Advancement of Science which has had a standing committee of co-operation and advice. The Association also supported the finances, in which it was aided by the Zoölogical Society and by the Royal Society. The author has consulted not only English but continental and American works. The list of such works, and their authors, occupies 46 pages. The plan of the author gives really two indexes, one of all specific names and one of all genera. The specific names may have been applied in numerous

genera. The work lists every such application and gives also the date of its publication with exact reference to the authority. In the generic catalogue only the species that have been described under each genus are given, without references to authorities. Here appear certain interesting features. The specific names are nearly all adjective in form and found in the Latin language. The Greek-derived terms are conspicious by their absence or rarity. Entomology takes the lead. Curculio has 1137 species. Ichneumon has nearly as many, also Musca, Papilio has about 2000 species, named between 1758 and 1800, and Phalæna about 5000.

The work issues from London, C. J. Day and Sons, Cambridge University Press, and is distributed by the Syndics of the Cambridge University Press. N. H. W.

Das Sonnwendgebirge im Unterinnthal, ein Typus alpinien Gebirgsbaues. VON DR. FRANZ WAHNER. Erst. Th., 96 illustrations, 19 photographic plates and a geological chart. 365pp. Leipzig and Vienna, 1903, Franz Deuticke.

This beautiful publication is devoted to an examination of a portion of the Alps to which have been given the study and the field labor of many geologists. The author analyses and abstracts very liberally the publication of his predecessors from 1819 (Uttinger) to 1899 (Böse), including Bittner, Mojsisovics, Wähner, Frech, Lechleitner, Pichler, W. B. Clark, Geyer, Klipstein, Diener, Gümbel, Zittel, Richthofen, and others.

Whatever may have been the cause of other portions of the Alps, the author's exposition makes it plain that this portion is composed of upthrust and crumpled sedimentary strata. The principal fossils belonging to these formations (the Lias with associated hornstones, gypsum, breccias, dolomytes, etc.), are enumerated. The faults and breccias are described. The stratigraphic succession is many times defined and illustrated at critical points by colored photographic plates. These plates are constructed on a new plan. The engravings, made from photographs, are colored so as to indicate the position and outlines of the different parts of the Lias, as they strike across a cliff or are broken and nipped in the adjacent stratification. This produces a very effective picture.

This is a first-class publication, a great credit to the Society for the Promotion of Science in Bohemia under whose auspices it is published. If it were supplied with a good alphabetical index it would compare well with the best American works of this nature. N. H. W.

On the Lakes of Southeastern Wisconsin. By N. M. FENNEMAN, Professor of Geology, University of Colorado. Wisconsin Geological and Natural History Survey, E. A. BIRGE, Director; Bulletin No. viii. Pages 178; with 36 plates, and 38 figures in the text. Accompanied by 9 folded maps of lakes, each with explanatory text. Madison, Wis., 1902.

This bulletin contains very full descriptions of the physical geography and geology of numerous lakes and their vicinity, including

lake Beulah, Elkhart lake, Oconomowoc and other lakes of Waukesha county, the Chain-o'-Lakes in Waupaca county, Delavan and Lauderdale lakes, Green lake, Big Cedar lake, and lakes Mendota and Monona, adjoining Madison. Much attention is given to the effects of glaciation in producing the multitudes of small lakes in this region, and to the action of the lakes in modification of their shores.

Lake Winnebago, larger than any of these, but comparatively shallow, is expected to be the theme of another bulletin; and an atlas of the chief lakes of the state is in preparation.

Lake Mendota, having an area of 15 square miles, is the largest here described; and Green lake, measuring 237 feet in depth, is the deepest. The maps show admirably the contour of the lake beds, which, not less than their shores and the surrounding country, give evidences of the glacial history to which mainly they owe their origin.

W. U.

The Origin of Certain Place Names in the United States. By HENRY GANNETT. Bulletin of the U. S. Geol. Survey, No. 197. Pages 280; Washington, 1902.

Historians and antiquaries will welcome this very satisfactory compilation of the origin and meaning of about seven thousand geographic names, representing, though far from completely, all parts of our country. This work may desirably be much further extended, for which the author invites "criticisms and additions, with a view to obtaining in the future all possible information on this subject." It is a field of especial attractiveness for students of geography, history, and philology. Very advantageously may our state historical societies gather all details in their respective states, as is now being done in Minnesota, for their own publications and for contribution to the great work planned, and thus begun, by our national survey. W. U.

Bornholms Paradoxideslag og deres Fauna, af KARL A. GRÖNWELL [Danmark's geologiski Undersogelse, II Række Nr. 13, Kjobenhavn, 1902.]

This admirable and comprehensive essay gives an excellent review of the epitomized sections of the Cambrian terrane of the island of Bornholm in the Baltic sea.

Previous to the issue of this publication, work had been done on the Cambrian of this island by Prof. F. Johnstrup and others, and the fauna obtained compared with those of localities in Sweden and Norway, but this work goes much more thoroughly into the treatment of the fauna in all its aspects than has hitherto been attempted.

The collections are chiefly from two localities—Læsaa and Borregaard at Aa. When it is understood that the whole thickness of the Paradoxides at one of these localities is but little over 2 metres, and at the other not much over 3, it will be seen of how little bulk the Middle Cambrian is in southern Scandinavia.

Mr. Grönwell was unable to find the full development of the Paradoxides beds, as seen at Andrarum in Sweden, on this island,

and gives a more condensed view of the succession, condensing the six lower zones of Andrarum into one, that of Paradoxides tessini, but he divides this into three sub-zones, beginning with that of Conocoryphe exsulens.

An interesting feature of these Bornholm sections is that while at one locality where the limestone of *C. exsulens* is present, at the other there is a bed of clay. Hence Mr. Grœnwell assumes that this is a residual clay due to the decomposition of the limestone, and removal by solution of the lime. The fossils in the gray clay at Læsaa show it to be of the same age as the limestone of Aa. At the base of the Exsulens limestone there was at Bornholm an erosion, cutting out about 5 metres of measures, as known on the Swedish peninsula.

The genus Agnostus is well represented in the Paradoxides beds of Bornholm, both as regards individuals and the number of species, Mr. Grœnwell describes twelve new species, or varieties of species, already known.

Microdiscus is found in two forms, *scanicus* and *eucentrus*, the author reduces the latter to a form or mutation of the former.

Conocoryphe is quite fully treated and shown to contain four subgenera: (1) Conocoryphe, Corda (s. str.), (2) Erinnys, Salter, (3) Ctenocephalus, Corda, and a new subgenus (4) Liocephalus, established to contain *C. impressa* Lnrs., *C. lyelli* Salt, and probably *Holocephalina*, Salt. [It seems doubtful if the last genus should go in its entirety to Conocoryphe, especially *H. inflata*]. Three new species are described under this section.

Paradoxides. Mr. Crönwell is inclined to think, *P. brachyrrachis* Lnrs, a separate species from the Bohemian *P. rugulosus*, to which it has been referred. He finds a variety of *P. sjogreni* Lnrs, (*nepos*) of much later time than the typical form.

Dorypyge, Dames, is represented in two new species of the Bornholm beds, which helps to give this genus a lower position than originally determined by Dames, as one was found in the Exsulens limestone, and both below the Andrarum limestone. This is parallel to the conditions in eastern North America, where the genus is found in beds with or below the representative of *Paradoxides tessini*. [The occurrence of these early forms of the genus seems related to shallow water and rough shores.]

Corynexochus has been found in good examples, including a new species, *C. bornholmensis*. Anomocare is represented by forms already described (by Angelin) and by a new one, *A. angelini*. Of Liostracus, two new species are described, and of Ptychoparia, one. Solenopleura has one new species, and Agraulos, one. [It seems questionable whether this form should be referred to Agraulos; it might with equal propriety go to Anomocare.] A solitary ostracod and gasteropod give further rarity to the fauna.

Comparisons are made with Paradoxides beds in other parts of the world, as various parts of Scandinavia, Wales, Bohemia, North America, China, &c. A very nice distinction, only possible in such a region

as Scandinavia, where the Cambrian fossils have been so thoroughly worked out, is that between the district of S.W. and N.E. Scandinavia, where not only were the physical changes to some extent, distinct but occurrence or absence of the subfaunas was consequent upon these differences.

Four superb plates of figures, chiefly of the new species and forms, add to the interest and usefulness of the volume. With this book in hand of those of Linnarsson, Brögger, Wallerius and others, one is able to get a very satisfactory understanding of the Cambrian species of the Scandinavian peninsula and islands; including many species of Angelin, upon which much obscurity rested owing to imperfect figures and very brief diagnoses of the species in the "Paleontoligica Scandinavica."

An English summary of the contents is bound up with this book.

G. F. M.

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PERSONAL AND SCIENTIFIC NEWS.

PROFESSOR D. E. WILLARD of the Normal school at Mayville, N. Dak., has been appointed professor of geology at the state agricultural college at Fargo, successor to C. M. Hall, lately deceased.

DR. G. P. MERRILL OF THE U. S. NATIONAL MUSEUM has been appointed expert special agent of the Census office in connection with the collection of statistics relating to stone quarries. The appointment in no way affects Dr. Merrill's position as head curator of geology in the museum.

MR. H. W. SHIMER has been appointed lecturer in Historical Geology and Palæontology at the Massachusetts Institute of Technology, Boston, for the remainder of the year. He succeeds Miss Elvira Wood who has gone to Washington, D. C., on the U. S. Survey as assistant to Mr. Walcott.

DR. JAMES FURMAN KEMP, professor of geology in Columbia University, delivered a lecture on "The discovery and development of mining districts," at Northwestern University on Saturday evening, February 7th. The lecture was illustrated by lantern slides and was given under the auspices of the University Guild.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting of this society on Wednesday, February 11th, the following program was presented: "Chitina copper deposits, Alaska," W. C. Mendenhall; "An anthracite coal-field, three and one-half hours west of Washington," David White; "The structure of a portion of South Mountain, Pennsylvania," George W. Stose; "Abandoned stream gaps in northern Washington," Geo. Otis Smith.

THE CLAYTON STONE AXE. This is another axe from the loess, described by Dr. C. A. Peterson in *Records of the Past* for January, 1903, found at Clayton, near St. Louis, in the construction of a belt railroad. It lay at the bottom of the loess, fifteen feet below the surface, and has the form and appearance of a neolithic instrument. The loess at that point lies on a tenacious red clay which may be the analogue of the geest underlying the loess at Lansing where the recent discovery was made of human remains.

THOMAS CROWDER CHAMBERLIN. On Saturday afternoon February 7th, a marble bust of professor Chamberlin was presented to the University of Chicago by a number of his geological friends and admirers, chief among whom was professor J. C. Branner of Stanford University. In the absence of professor Branner the presentation of the bust to the University was made by professor C. R. Van Hise of the University of Wisconsin. A response was made by president William R. Harper of Chicago University, and remarks were made by Dr. H. Foster Bain and professor R. D. Salisbury. Letters were read from professor Samuel Calvin, Mr. Bailey Willis, professor H. L. Fairchild for the Geological Society of America, and Mr. S. F. Emmons.

THE AMERICAN MUSEUM of Natural History of New York city, has sent Dr. E. O. Hovey to the Lesser Antilles

again to supplement the studies which he made last summer on Martinique and St. Vincent. Dr. Hovey left New York by the steamer Martinique of the Quebec line on February 4th, and will remain in the Windward and Leeward Islands two months or more. After studying the changes which have taken place on Martinique and St. Vincent as a result of the great eruptions which have occurred since last July, he will visit all the other important volcanic islands of the chain to photograph their craters, solfataras and boiling lakes, with the idea of making his final report upon the eruption of 1902 in the West Indies comprehend the entire series of Caribbean volcanoes. He will make collections of volcanic rocks and other materials for the Museum.

A New Division of the United States Geological Survey. A new division, to be known as the division of hydrology, has recently been organized in the hydrographic branch of the United States Geological Survey. The work of this division will include the gathering and filing of well records of all kinds, the study of artesian and other problems relating to underground waters, and the investigation of the stratigraphy of the water-bearing and associated rocks. In addition to the gathering of statistics relating to the flow, cost, etc., of the wells, it is hoped in the future to give especial attention to the geologic features which govern or which are related in any way to the supply of water.

The division will be subdivided into two sections, the eastern and the western, the first embracing the Gulf and Mississippi River states and the states of the east, and the second embracing the remaining ("reclamation") states and territories, or those having public lands. The charge of each section has been assigned to a geologist, the western section to Mr. N. H. Darton, and the eastern to Mr. M. L. Fuller. The office details are in charge of Mr. Fuller.

The sections will be still further subdivided so that each state or group of adjacent states shall constitute a district in which the work of collecting data and of investigating the problems relating to underground water will be in charge of a geologist employed for the purpose.

In the western section it is expected that the study of the geologic structure will be followed by the sinking of wells by the Survey, the aim being to test such of the arid or semi-arid regions as appear to present conditions favorable for artesian water, with a view to their ultimate development for agricultural purposes.

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CHARLES MONROE HALL.

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THE LIFE AND WORK OF PROFESSOR CHARLES M. HALL.

By WARREN UPHAM, St. Paul, Minn.

PORTRAIT—PLATE XIII.

In the comparatively new states west of Minnesota, resident geologists are few. Many problems of theoretic and economic geology wait there to be worked out. The death of a young geologist, who was well equipped and earnest for this work, who had grown from boyhood to manhood in North Dakota, whom to know was to esteem and love, is therefore a great loss, not only to his personal friends, but to the wider interests of education and science.

Charles Monroe Hall was born in Wellington, Ohio, October 21, 1870. When he was about twelve years old, his parents and the family removed to North Dakota (then a part of Dakota Territory), settling in Stutsman county, near the present town of Eldridge. Later they removed to Grand Rapids, on the James river in La Moure county, where they engaged several years in farming. In 1891 his parents removed to the state of Virginia, where they have since resided. Charles, however, preferred to remain in North Dakota, entered the State Agricultural College at Fargo, went through the usual course of four years, and was graduated in 1895, with high honors.

Immediately after his graduation, he was appointed assistant professor of chemistry and geology in that college, where he taught during the next two years. To better qualify himself for his duties there, he then obtained a leave of absence for a year of special studies in Johns Hopkins University.

Frederick Bennett Wright, his room-mate during this year at Baltimore, writes: "In the autumn of 1897 Mr. Hall entered the graduate department of geology. His enthusiasm in the work, together with his attractive personal characteristics, soon won for him a genuine popularity within the circle of geological professors and students among whom he had come. Although his interest in the work before him was general, he was more attracted by structural and physiographic subjects than by those of mineralogy and paleontology. His life at Fargo, in the old bed of lake Agassiz, naturally gave him a keen interest also in glacial geology. During his stay at Johns Hopkins, he worked for a short time on the Maryland Geological Survey, along the Potomac river. There his work was so thorough and satisfactory that he was offered a position in that state survey, for field work on the coastal plain the following summer. But his teaching and plans for field work in North Dakota were more attractive and caused him to return there. Personally he was very modest about his accomplishments, but yet had a sufficient sense of their importance to give him the confidence in himself necessary for success. I was greatly impressed with his broad views on all subjects, and his wide interest in general topics. We often had heated discussions, though perfectly friendly, which sometimes lasted till after midnight, on all conceivable subjects, from geology, evolution, and theology, to music and art."

Returning in the summer of 1898 to the Agricultural College of North Dakota, and being promoted to its professorship of geology, Hall was constantly engaged, through the remaining four and a half years of his life, in his duties as a college instructor, including frequent excursions with his classes, and in more extensive examinations of distant parts of the state during vacations.

In the summer of 1900 he began a systematic investigation of the artesian wells and underground water resources of North Dakota, through co-operation by the Agricultural College with the United States Geological Survey. Previously also he had aided professor J. E. Todd, during one or two summers, on similar work in a part of the James river valley in South Dakota.

Besides the hydrographic work, he began at the same time a survey of the soils of North Dakota, being associated with

F. H. Newell and Milton Whitney, of the U. S. Geological Survey, in their respective departments of hydrology and soil investigations. Manuscript reports and maps, notes of stream measurements, records of artesian wells, collections and analyses of soils, etc., relating to parts of these researches already completed or well advanced, had been forwarded to Washington, but they still await publication.

Professor Hall had presented some of the results of this work in a series of newspaper articles, concerning the water supply of Fargo, the artesian basin and wells of the Red river valley and westward, irrigation for the drier western parts of the state, and the capabilities of its different regions for agriculture and grazing, these articles being published in the Fargo *Forum and Daily Republican,* the Wahpeton *Gazette,* the Minneapolis *Journal,* and other newspapers, during the years 1900 to 1902.

One of the most important of these contributions is entitled "A Discussion of the Water Resources of Fargo and Vicinity, with special consideration of possible sources of water for a better supply for the city," which filled four columns of the *Forum,* June 24, 1902. It is accompanied with a section across the Red river valley, on the line of the Northern Pacific railway, and a map which shows the limit of the chief artesian basin, receiving water from the Dakota sandstone, and the smaller areas of the valley receiving usually scantier flows from the drift deposits.

Within the last month before his death, he completed a manuscript for the supplement in a school geography to be published by the American Book Company, this supplement being a "Geography of North Dakota."

Professor Hall represented his state through appointment by the governor, in the Tenth National Irrigation Congress, held at Colorado Springs, October 6 to 9 of last year; and in the Fargo *Forum* of November 22 he published a considerable report of its proceedings, with earnest recommendation that North Dakota should take a larger share, in connection with the U. S. geological and hydrographical surveys, for the development of irrigation.

The latest and perhaps the most important work which professor Hall brought to completion and publication, as print-

ed in December, 1902, is an "Official State Map and Preliminary Geologic and Economic Map of North Dakota, issued by the Agricultural College Survey . . . in co-operation with the U. S. Geological Survey; approved by Frank White, Governor of North Dakota, and R. J. Turner, Commissioner of Agriculture and Labor." The scale of this map is seventeen miles to an inch. The western half of the state, and the Turtle mountains, are colored as Laramie clays and shales, with many outcrops and mines or openings of workable lignite. Thence eastward the remainder of the state, excepting the area of the glacial lake Agassiz, is colored as glacial drift overlying the Montana shales of Upper Cretaceous age. Upon these colors the courses of the marginal moraine belts are shown by another color printing. On the eastern border is the part of lake Agassiz west of the Red river, with its large Sheyenne, Elk Valley, and Pembina deltas. The extreme limit of the glacial drift, and the boundaries of the Dakota artesian basin, are designated approximately.

October 22, 1901, professor Hall was married to Miss Jessie E. Taylor, of Fargo, and their life together was one of remarkable happiness and mutual helpfulness. They both were members of the First Methodist Episcopal church of Fargo, and of its choir. Professor Hall was also a member of the Masonic fraternity, the Knights Templar, and other social organizations.

His last illness was diagnosed by physicians, half a year before he died, as probably to prove fatal within a year, or, at the longest, a few years. Yet he courageously continued his teaching and his plans for the state agricultural survey. One of his last pieces of work was to frame a legislative act giving to that survey, as aided by that of the United States, a distinct field not duplicating the work of the State Geological Survey, which is in progress under the auspices of the State University and School of Mines of North Dakota, at Grand Forks. His work of instruction in the college was continued until only three days before his death, which occurred at his home in Fargo the 22nd of January, 1903. For him is the divine promise, "Be thou faithful unto death, and I will give thee a crown of life."

PROFESSOR JAEKEL'S THESES ON THE MODE OF EXISTENCE OF ORTHOCERAS AND OTHER CEPHALOPODS.

By RUDOLF RUEDEMANN, Albany, N. Y.

Professor Otto Jaekel presented at the February (1902) meeting of the Deutsche Geologische Gesellschaft the following theses, which were discussed at the March meeting and at a special meeting in April.*

"1. We should not conceive of the orthoceratites as free-swimming organisms, but, like the colularias, actually sessile in such a fashion that their chambered shell grew upward from a bell-shaped fixed embryo-chamber and throughout life retained flexible connection with this by means of conchioline secretions.

"2. The formation of septa and cameræ served, as in corals, Hippurites and some sessile, erect gastropods, to lift the body above the sea bottom (growing upward by sedimentation), without necessitating an essential alteration of its form, and also to facilitate the upright posture of the shell and its animal on a relatively small base.

"3. The siphonal cord then appears to be that portion of the body which is reduced by the formation of cameræ. As compared with other animals bearing chambered shells its formation becomes intelligible by the fact that the body grows only secondarily from the original fixation or embryonal chamber, and that the latter was hence an integral part of the original body.

"4. The siphonal calcareous secretions (obstructive rings and endosiphonal calcareous deposits in the lowermost part of the shell of the endoceratites) serve to ballast the body so as to counterbalance the formation of air chambers, which latter guarantee an upright position.

"5. The involute Nautiloidea in the restricted meaning, have discarded fixation, either from the beginning or in later stages of their development. Their protoconch consisted of conchiolin and was therefore not capable of preservation. For this reason, it cannot be determined whether it was retained by

* Published in *Zeitschr. der Deutschen Geol. Gesellsch*, 54 Bd., 1902, p. 67-101.

the animal on the shell or whether the chambered portion of the shell parted from the protoconch. Both cases are possible, the former more probable. I have seen its oval impression on the succeeding volution of a *Nautilus barrandei* from the alpine Keuper. The first chamber of the Nautiloidea is hence not the protoconch, but the first air-chamber, which at the lower end shows a scar for the passage of the siphuncle from the protoconch into the chambered portion of the shell like that in the orthoceratites.

"6. The semi-involute Nautiloidea, the cyrtoceratites in a broad sense, are not transitional types from the orthoceratites to the involute Nautiloidea, but regressive types of the latter. The involution in every case presupposes a free state of the individual, hence at least an early detachment if not an absence of attachment.

"7. The forms with contracted ostium or aperture, as *Gomphoceras, Phragmoceras, Tetrameroceras, Hexameroceras,* were probably imbedded in the silt with their entire shell and protruded only their arms and their funnel, which here as in other mollusks was a sipho, i.e. a breathing tube.

"8. The ammonites and belemnites were free from their inception, as they have retained their embryo-chamber in form of a calcareous ovoid bulb on their chambered shells.

"9. The rostrum of the belemnites was not a rostrum, i e. a water-cutter, but a *paxillus,* a post to be driven into the ground; the belemnites were hence not free and, as generally supposed, rapidly swimming, but were sedentary animals.

"10. The higher "Dibranchiates," the ink-fishes proper, have become crawlers or have acquired a retrograde swimming motion by means of the funnel. With the exception of the cuttle-fishes, which developed from the belemnites and which, in *Spirulirostra* and *Spirula,* show interesting regressive characters, the skeleton of the remaining dibranchiates, is reduced either completely in the benthonic, essentially creeping octopods, or has, after complete obliteration of the "rostrum," become a flexible axial support, which consists of conchiolin and is comparable to the vertebral column, in the slender Oigopsidæ which became better swimmers and possess even paired terminal fins.

I beg to add the following theses on the relation of the cephalopod to the other mollusks:

"11. I consider as progenitors or as proseries of the cephalopods, the conularias, in which the body form and shell secretion of the orthoceratites was inaugurated and the formation of four gills, which it would be difficult to derive from the body form of the cephalopods, was established. Lateral members of this proseries we find in the Hyolithidæ, which present in their incomplete formation of septa and the well developed formation of opercles, certain analogies to the cephalopods. (The aptychi are herein considered as cuticular calcifications of the hood, which in Nautilus serves for external closure of the ostium.)"

Professor Jaekel made some general remarks on the form and purpose of these theses from which we learn that the form in which they are presented is simply to invite discussion. This appeared necessary because the biological consideration of these extinct mollusks has gradually fallen too far behind their morphologic and systematic treatment, and it can be hardly disputed that with such aberrant types as the orthoceratites and belemnites an understanding of their organization can be attained only by thorough consideration of their mode of life. As the meaning of changes in organs can be ascertained only in a biologic way, and while the paleontologist has perpetually to deal with processes of alteration, there is also in this field the necessity of the biologic mode.

In explanation of theses 1 and 4, which refer to the organization of the orthoceratites, we find the following remarks:

"With the view hitherto current that the orthoceratites moved through the water like the slender squids of the present (Oigopsidæ), that hence the apex of the orthoceracone was directed forward when in motion and served as a water-cutter, the following parts of their organization seem to me to be specially at variance:

"a) The calcareous shell of the orthoceratites is much too thick and heavy for a pelagic habit, moreover it is in some forms often loaded with special calcareous secretions.

"b) The external sculpture of the shell excludes the possibility that the latter could have been imbedded in the flesh of the body; hence active swimming organs could protrude only at the apertural end of the shell (*ostium*).

"c) The shell not only frequently shows a pronounced transverse sculpture, but it may even be provided with ring-like swellings (annulate forms). Both phenomena are irreconcilable with a rostral function of the shell, as both would offer friction and resistance to the water pressure.

"d) The strictly symmetrical form of the shell contrasts sharply with the shells of the squids, nor does it, aside from its heaviness, find an analog in the shell form of the pteropods, which also fail to display any such pronounced monaxial bilateral symmetry.

"e) The straight truncation of the ostial margin, together with the symmetrical form of the whole shell, excludes also the possibility that the orthoceratites were crawlers bearing their shells on their backs after the fashion of snails.

"On the other hand, the following facts argue, in my opinion, for the *sessility of the orthoceratites*:

"a) The radially symmetric structure, which everywhere in the animal kingdom is characteristic of sessile forms, appears in the circular section, the straight truncation of the aperture of typical orthoceratites, the position of the three or five submarginal impressions in the living chamber, the regular growth in thickness and an occasional regular, radially symmetric arrangement of longitudinal ridges upon the surface, and can be readily explained only by conditions of static pressure during growth.

"b) The shell is usually broken off at its lower end; which is an exceptional condition in externally similar gastropod shells such as Fusus, Turritella, Terebra or in the very slender shells of pteropods. Among the thousands of observed orthoceracones initial chambers have become known in but a few forms. The apex is hence nearly always broken, a fact which indicates that it was held by an external force after the death of the animal. In those cases where the apex has been observed in well preserved state, it shows a scar which, like that at the first air chamber of the ammonites, apparently permitted to the siphо a connection with the contents of a protoconch as yet unknown.

"c) The agreement of the shell structure of the orthoceratites with the conularias seems to me unmistakable. The latter show a radially symmetric structure; with them a trans-

verse sculpture predominates; among them the apex is commonly broken off; further their pronounced tetramery appears to me to throw light upon some hitherto unexplained facts of the organization of the cephalopods, such as the possession of four gills among the older cephalopods, a condition which, as is well known, is eventually lost in this class and yields to dibranchy; and further, upon the remarkable tetramerous cell division of the cephalopod embryos. While we have until lately, been without any clew to the mode of life of the conularias and from the external similarity of the shell with that of certain pteropods have inferred a pelagic habit for these organisms, Ruedemann in Albany, U. S., has made a discovery, which is most interesting, though little noticed in literature, namely a colony of young conularias fastened by a relatively large, conically attached basal chamber to the sea bottom or to other objects. (R. Ruedemann. The discovery of a sessile Conularia 15th Ann. Rept. of the N. Y. State Geologist. Preliminary partial reports in the AMERICAN GEOLOGIST, 1896, xvii, p. 158; xviii, p. 65.)

"Proceeding from certain ideas stated by A. E. Verrill (Amer. Jour. of Science, 1896, v. 2. p. 80) Ruedemann has briefly expressed the opinion that the conularias might be the ancestors of the cephalopods. To the probable objection that, in distinction to the calci-testaceous cephalopods, the conularias possessed a chitinous skeleton, he points to Chrondrophora with its chitinous skeleton and states in accordance with the views of Hyatt and others, that the initial chamber of various nautiloids might have been chitinous. In regard to this I would remark, that, in my opinion, the shell of the conularias did not consist of chitin, but of conchiolin and hence was in principle like that of the molusks. Moreover, [as stated by Ruedemann,] we find in various phyla of the animal kingdom, as Anthozoa, Bryozoa, Brachiopoda, that so-called horny skeletons precede the calcareous.

"Ruedemann holds the view that the conularias were sessile only in their youth and later became free, or at least could quite likely be so. The acceptation of such a possibility seems to me to be essentially a concession to the old view concerning these forms, and has probably not been confirmed since. Besides, this assumption would be opposed by nearly the same

considerations as the free mobility of the orthoceratites. But as here the fixation of younger individuals and of very different sizes, has been proved, and no fact in the shell structure of mature conularias points to other biologic relations, we are not only justified but bound to assume also a fixation of the mature conularias until the contrary has been demonstrated. From the Upper Siluric of Ludlow in England (Lower Ludlow beds) I have collected a conularia having a hight of ca seventy cm. and hence surely to be considered as fully grown, and which, at its pointed end, shows, corresponding to some growth-stages figured by Ruedemann, such striking phenomena of bagging in its growth, that I believe I am justified in citing it as a direct argument for persisting sessility.

"d) A transverse cameration of a shell, i.e. in its primitive form, an advancing in the shell by means of the formation of septa, is found without exception among sessile organisms,* not only as a typical character of certain groups of life forms, as the corals, Chætetidæ Sphinctozoa, but also singly in other divisions and specially such as, in contrast to their relatives, combine attachment with vertical growth, such as Richthofenia among the brachiopods, Hippurites among the bivalves, Vermetus among the gastropods. Such cases as these make cameration appear as a result of vertical sessility and therefore allow us to infer from such cameration, this sessile mode of life.

"Under the former mode of construing the orthoceratites it would have been difficult to cite any probable reason for the cameration. On the contrary it would be very strange if just that part of the shell had been rendered most fragile by the formation of air-chambers, if in swimming it would, as rostrum, have had to possess the greatest power of resistance.

"Of special moment is the consideration that the formation of air-chambers may have largely diminished the body weight of the orthoceratites and thereby have counterbalanced the pressure which otherwise would have rested upon the apex of the shell. The latter was thereby largely strained by an upward pull at the basal chamber and under these circumstances the structure could hardly have been more advantage-

* "The chambered calcareous foraminifers can not here be used for biologic comparison, as all chambers are filled with protoplasm and cameration does not involve a separation of the animal from the posteriorly situated chambers."

ous. For the fixation at one point allows a balancing movement in all directions and may be conceived to have been affected by vertically stretched ligaments, which, ring-like, embrace the initial shell. The orthogenetic* formation of the chambers exerts an increasing pull upon the chamber of attachment, and as a completed structure, by the law of acceleration, appears in successively earlier stages of the ontogeny, it is obvious that cameration finally led to detachment among a part of the forms.

"e) The siphonal cord which has always been the most peculiar enigma in the cephalopod organization, has found very different interpretations, but none of these has been accepted as wholly satisfactory. It can hardly be considered as an organ of fixation for the shell, because, on one hand the animal is held in the living chamber by a muscle of attachment, and on the other hand the siphuncle in Nautilus has by no means the histologic character of a ligament, and finally it would remain unintelligible why it then perforates the whole shell throughout lifetime and is not concentrated upon the last septal wall.

"If we now proceed from the idea that the chambered cephalopod shell originated from a sessile protoconch, the formation of the siphuncle appears at once in quite different light. *The siphuncle is then nothing but a portion of the body restricted by the formation of the chambers. It becomes biologically analogous to the umbilical cord of the mammals, more specially however to that portion of the pelmatozoans, which is constricted by the stem joints,* and these analogies appear also for that reason to be not without meaning, for various facts point to phylogenetic relations of these types. I will hereby exclude at once the supposition that I would derive the vertebrates from the cephalopods or pelmatozoans, on the contrary, in my opinion, some facts seem to argue for a derivation of the mollusks as well as of the echinoderms from higher types of the group of the episomatides by repression of development (O. Jaekel. Uber die Stammform der Wirbeltiere; Sitz.-Ber. Ges. naturforsch. Freunde, Berlin, 1896, S. 116).

"According to this view the siphonal cord would enclose a portion of the somatic cavity, which kept the embryonic body

* O. JAEKEL. Ueber verschiedene Wege phylogenetischer Entwicklung. GUST. FISCHER. *Jena.* 1902.

in connection with the definitive body. The analogy with the crinoid stem extends further also on genetic and histologic relations. In both the tubes are wide in the older forms and become more and more constricted in the later by expulsion of the intestines. . . . In older crinoids with wide stems, the cord must have enclosed a considerable portion of the somatic cavity and have been in connection with the root, but in later forms this whole portion has been reduced to a fibrous tissue that no longer shows distinct processes of differentiation and therefore has been differently interpreted (Comp. Jaekel in Stammesgeschichte der Pelmatozoen, I, 1890, p. 77-79).

"Very similar are the special conditions of the formation of the siphuncle. In the older forms it is frequently very wide; with the later it is mostly narrow, and it becomes finally rudimentary when the shell was never attached.

"The remarkable expansions of the siphonal tube of orthoceratites, which hitherto could not be accounted for, would now appear to find their explanation in the supposition, that a constriction of the air-chamber would increase the weight and thereby the stability of the shell upon the bottom. The siphonal calcareous secretions would also have to be regarded as for the same purpose."

Our space does not permit us to reproduce here the author's explanatory remarks of his theses 5 and 6, but we consider the views presented on behalf of thesis 7 so suggestive that we cite them in part:

"To thesis 7, referring to the contraction of the ostium of various nautiloids, as in Gomphoceras, Phragmoceras, Tetrameroceras and Hexameroceras, I desire to add the following explanation: To begin with, it cannot be doubted that according to the current view the single median sinus [of the aperture] corresponds to the position of the funnel, and that the paired symmetric sinuses of the infolded upper shell-margin embraced the arm bases and that hence the mouth lay between them. These are the only fossil ammonoids which give some clew to the form of the cephalosoma and specially to the position of the arms on the head, but which still have been little considered in this connection. The interest in these ostial forms is still hightened by the fact that of nearly related forms, such as Tetrameroceras, Hexameroceras, Octomeroceras, the

one possesses four, another six, the third eight, Phragmoceras and Gomphoceras however but two sinuses, which obviously denote separate arms. One conceives, now, the development of the arms usually thus; that in nautiloids numerous arms were present in indefinite number, and that the latter consolidated in the younger types to ten (decapods) and to eight (octopods). It is however, according to the ontogenetic development of the arms of the living dibranchiates and the morphologic arrangement of the so-called head tentacles of Nautilus, much more probable that the latter are but evaginations of the arms, which quite likely do not correspond to the single arms of other cephalopods.

"Hexameroceras osiliense shows on either side three arms sinuses which gradually increase in size upward from the funnel sinus. The figure presented by their arrangement may be directly compared with growth-stages of living dibranchiates. . . . While in the mature sepia the arms surround the mouth radially, their inception is a paired one with a distinct symmetry, so that with the appearance of the last arms the mouth becomes surrounded and enclosed by the circle of arms. Two pairs are developed first and these are soon followed by the third. These three pairs may also here be indicated and in the case cited may have flanked the mouth laterally. The encircling of the mouth, which ontogenetically takes place at a late stage, had here not yet been accomplished. The circle is interrupted by a hood, partly overhanging the mouth as in Nautilus, in which however the formation of the arms has been specialized in quite different direction from that of these Siluric types. In the oral view of Nautilus one sees what can not be learned from the current representation of the animal, namely that the mouth in the center is flanked on both sides by three leaf-like compressed arms, which are provided with muscular, contractile, transversely striated tentacles. . . . As to their ontogenetic succession of position we know unfortunately nothing and one must consider the exterior and strongest as homologous to the first arm of the dibranchiates, the inner ones as the second and third pairs, which are more distant from the funnel. . . . We can not conclude that in these forms the funnel was, in contrast to Nautilus, open upon the oral side simply from the fact that [in Hexameroceras,

etc.] the shell parts approaching each other above the funnel leave a slit open between them. Its inception in all dibranchiates argues for the secondary coalescence of the walls. There is on the whole little probability that a funnel like that of Nautilus was placed under this slit; we will hardly be amiss if we locate the arms in the aperture which is directed aborally backward. The funnel in the typical form of a folded muscle-plate, as it is found persistently in Nautilus and embryonally in the dibranchiates, or in the specialized form of a distally circular, coalescent tube, as in the mature dibranchiates, presents probably specialized conditions adapted to the peculiar mode of movement of free living cephalopods. I consider it probable that the arms of these older nautiloids were spread out blade-like and, as in Nautilus, provided with erectile tentacles. The contracted aperture of several ammonites appears so similar to that of the gomphoceratites, that one may at least infer blade- or spathe-like arms. . . .

"The activity of these forms can hardly have been very great or comparable in any way to that of recent dibranchiates. The advanced closure of the shell suggests the balanides and lepadides, the bryozoans and various types of worms as serpulites, and seems, therefore to suggest the probability that these for genera mentioned (Hexameroceras etc.) were sessile. The manner in which the shell conformed itself to the arm-bases appears most easily explained as a special provision for preventing an intrusion of foreign bodies between mantle and shell. This fact, pointing to a strong dependence upon the bottom, together with the bilaterally symmetric form of the shell, has led me to the supposition that these animals lay imbedded vertically (hence symmetrically) in the bottom of the sea and spread out their arms upon it. The strong projection of the funnel-sinus would also be explained by this supposition, as it then would have had to exercise the function of a real siphuncle. To colleagues, to whom this explanation may appear strange and bold, I wish to point out that some Spatangidæ lie buried about a foot deep in the sea bottom, protrude their long tentacles through a tube, and through another discharge, by energetic water current, the contents of their intestine. Here one has, therefore, quite analogous conditions, which would have hardly been expected from an echinid.

"It also seems important to me to recall here the fact that not only the living octopods, but also decapods like *Sepia,* hide in manifold ways upon or in the bottom, either by piling up stones and other foreign bodies upon them, or by stirring up with their fins so much sand that their back becomes entirely hidden. From such conditions to the supposed mode of existence of the pnragmoceratites, there seems to me only a short step. The firm attachment of *Spirula* at the bottom will, in this connection, find an explanation as a phenomenon of regression."

We omit here the remarks upon theses 8-10, interesting as they may be, as they refer to belemnites and younger dibranchiates, and are somewhat remote from the major propositions of the author.

The discussion which followed professor Jaekel's remarks was, judging from the record, both animated and instructive. Space forbids me to give more than meagre notes of the arguments and objections made. Professor Branco pointed out that orthoceratites, belemnites and gomphoceratites are never found in a vertical or erect position, while professor Beushausen mentioned the occurrence of long orthoceratites in vertical position in the Oneonta sandstone of New York, an occurrence made known by professor Clarke. (N. Y. State Mus. bull. No. 39, 1900, pp. 167-171.) Others found it difficult to understand how endoceratites often several meters long could have been supported upon a delicate apex and that the bases had never been found in sediments, such as clay, where all firm tissues are as a rule excellently preserved. These arguments were met by the declaration, that firm ligaments held the lower part of the shell upon the basis, that the vertical position of the shell was essentially effected by the air chambers and that the latter, after the death of the animal and the decay of the basal tissues may have drawn the shells away from the bases.

Specially interesting were the remarks of professor v. Martens, whose experience as biologist enabled him to illuminate from various sides the problem of the mode of existence of Orthoceras. V. Martens agrees with Jaekel in that the orthoceratites were not free-swimming or pelagic animals, as these have all extremely thin, fragile shells and are, in all classes of

the animal kingdom, bilateral, like a ship. If Orthoceras lived at the bottom it could have moved along as Sepia does,—the long conical shell is no proof of the contrary, as such gastropods as Cerithium and Turritella demonstrate. But it must then have had strong motive organs, directed toward the bottom, and if the shell was external, one would not expect to find an apertural plane vertical to the axis of the shell as in Orthoceras, but inclining toward the ventral side of the animal, as in the gastropods mentioned; if the shell were wholly internal, or at least on its anterior part, then it would, as in Sepia, adapt itself to the bilateral form of the animal, which in its turn adapts itself to the surface of the sea bottom. A conical, cylindrical or sack-shaped body with decided differentiation of both ends and uniformity in circumference is the characteristic form for animals of little motion, in which the upper and anterior ends are identical, i.e. for sessile forms, as certain infusorians, corals, crinoids, ascidians and cirripeds. A decided approach to this body form is, among the living cephalopods, found in Octopus, which prefers to sit in cavities of the rocky bottom and to extend thence his arms in all directions in search of prey. Mr. v. Martens stated further that the strong development of the calcareous shell in Orthoceras certainly argued for a very early sessility in the development of the young Orthoceras. The base of attachment may, as in Fungidæ and oysters, have been a very small stone or snail shell; the smallness of which may have forced the older orthoceratite to effect its static support by sinking its lower end into the soft mud.

Finally it was pointed out by the same investigator that one must not be afraid to assume within a class of quite uniform internal organization, a very great variety in the exterior mode of existence; the great difference in the external appearance indicates this distinctly, and it is actually found in many classes of animals, as among the gastropods, which are most closely related to the cephalopods, and also among the lamellibranchs.

We hope that these theses will be taken as such by American paleontologists, i.e. as challenges to a discussion of the biologic relations of the groups involved; and of the orthoceratites in particular. There is no doubt that such a discussion

will aid in rendering our conception of these forms more concise by bringing out observations stored up in the notes of investigators. With this purpose this translation has been prepared and the present writer desires to add a few annotations to these significant contentions.

It has been asserted on various excellent grounds that life originated in the coastal regions with benthonic forms; that slowly creeping organisms preceded the planktonic and nektonic forms in the lower phyla of the animal kingdom. This principle may, in its totality, be well applied to the Cephalopoda, for here all the living forms are mostly rapid movers in contrast to the evidently sluggish forms with heavy shells, belonging to the early geologic periods. In the Mesozoic we find the ammonoids, which for good reason, are now considered as bottom crawlers; and as we go back in time in the paleozoic we find the coiled forms largely replaced by the orthoceracones. Notwithstanding the fact that Barrande demonstrated that the whole series of forms from the straight to the involute nautiloids was present in the earliest period, and the declaration of Jaekel (in explanation of thesis 6) that the slightly curved forms are not transitional between the involute nautiloids and the orthoceracones, but are types of repression of development of the former, and that, further, the majority of these faintly involute forms do not appear until Upper Siluric and Devonic time, it can be statistically established, as Hyatt affirms, "that the straight cones predominate in the Silurian and earlier periods; while the loosely coiled are much less numerous, and the close coiled and involute, though present, are also rare." We cite here Hyatt's lucid exposition of these facts (Phylogeny of an Acquired Characteristic, p. 366):

"But suppose we reverse the course of nature and follow back the diminishing number of nautilian and gyroceran shells. We then see, upon arriving at the Silurian, that the vanishing point of these shells, although not traceable on account of the lost records of Protozoic time, could not have been far distant, while the increasing number and varied forms of the straight cones indicates for them a more remote focus in time and consequently a more ancient origin. Thus we are able to see that, antecedent to the Silurian, in the Protozoic, there must have

been a time when the straight cones or their immediate ancestors predominated, to the exclusion of the coiled and perhaps even of the arcuate types."

If now the orthoceratites were actually the earliest cephalopods we may, by application of the general principle regarding the origin of life, mentioned above, infer that they were certainly not free swimming forms, but either sluggish crawlers or wholly sessile. As the structure of their shells would seem to exclude the crawling habit, the sessile would remain by exclusion.

On the other hand, it can not be denied that facts present themselves which do not corroborate the theory of the sessile mode of life of Orthoceras. It becomes evident from Jaekel's remarks and explanations that the presence of "air-chambers" is considered necessary to relieve the apex of the shell from the weight of the shell and animal by the upward pressure of the contained air. The current view is thereby retained that the chambers of the cephalopod shells were "air-chambers" This view seems, however, by no means established, for Verrill (see Zittel-Eastman. Text book of Palentology, p. 508) states that the chambers of Nautilus stand by way of the siphuncle and pericardium in direct connection with the gill cavity, and adds: "Thus sea-water can readily pass into or out from the chambers of the shell, to equalize pressure at varying depths, as in most marine *Mollusca.* These chambers are unquestionably filled with fluid under normal conditions. But living as the animal does under pressure at considerable depths, the fluid in the chambers is saturated with the gases in solution. When the Nautilus is rapidly brought to the surface, some of the gas is liberated in consequence of diminished pressure, and must occupy part of the space within the chambers by forcing out some of the fluid. Hence the shell will float until the free gases within the chambers are absorbed or otherwise eliminated. There is no evidence that free gases are ever naturally present in the living chambers during life."

If the living Nautilus has its chambers filled with water, the inference is that the extinct cephalopods had it likewise. Hyatt has therefore properly proposed the non-committal term "cameræ" for the compartments of the cephalopod shell. The fact of the filling of the chambers with water would, however,

considerably alter the conditions of static pressure of the orthoceran shell. The calcareous siphonal excretions would then have hardly been intended to counterbalance the upward pull of the air-chambers and to furnish stability to the conch, they would rather appear to have increased the evil of pressure upon the apex.

Of special interest in this connection is the endoceratite, Nanno aulema Clarke, from the Trenton of Minnesota (Geol. Surv. Minn. v. 3, pt. 2; Pal. p. 770). This cephalopod had a wide proseptal siphonal cone, which is filled with solid limestone, a modification of the original organic deposit. This solid, heavy apical cone was "unquestionably," as Clarke asserts, "external except so far as ensheathed by a mere coating or film of the shell-tube." The chambered portion of the shell includes only a few relatively small chambers. This animal must have undoubtedly lived like the belemnites, and the apical cone must be functionally analogous to the rostrum of the latter. In regard to the belemnites it is claimed by Hyatt and still more definitely by Jaekel, that they buried themselves in the mud and used the rostrum as a post, "paxillus," as Jaekel terms it, to secure themselves in the soft ground. We have then in Nanno an orthoceratite of which we can claim that it followed the same praxis. This, however, gives us a hint as to the use of the heavy deposits in the siphuncle of the other endoceratites, as well as of Actinoceras, Hormoceras and the groups of species of Orthoceras, occurring in the Devonic Schoharie grit of New York. The most typical of these Schoharie grit species, Orthoceras luxum, pravum and oppletum frequently have their entire chambers solidly filled with organic deposits as examination of the plates of the New York Paleontology, v. 5, pt. 2, (f. i. pl. 81) will readily show. It is a very suggestive fact that this Schoharie grit is a sediment consisting of quartz sand in a limestone matrix, which by its composition and enclosed fauna indicates deposition in the littoral zone and in disturbed waters. It seems probable that these orthoceratites used the weight of their shells to anchor themselves in the sand and thus prevent their being torn from their moorings. But if these orthoceratites buried themselves in the ground, it is very probable that all the others did the same.

In this connection, it is still further to be considered that endoceratites of the Trenton attained a length of sixteen feet or more. While it is already difficult to understand how these giants could have balanced themselves upon their apex, it would appear still more unintelligible that they should have striven to raise themselves so high above the sea bottom when their recent descendants find it so much more advantageous to lie low in the mud and to prey upon the much richer fauna of the vagile benthos. Besides, in the Trenton period, the fish-fauna was certainly small and the majority of all organisms, which we have from that period, were still bottom-crawlers. These considerations suggest to me the supposition, that the orthoconic cephalopods may have fixed themselves only in their youth to small objects, to gain a foothold, as professor v. Martens suggested, but later on may have allowed themselves to sink, or actively worked themselves into the ooze and perhaps also may have piled sediments around them, in order to gain steadiness and to hide themselves. The occurrence of numerous upright orthoceratites in the Oneonta beds of New York also mentioned in the discussion of the theses, may serve to support this view, in case it can be proved that the orthoceratites were killed in situ by an inflow of fresh water, as is indicated by the presence of Amnigenias.

The objection that no other orthoceratites, with the exception of those just mentioned, are found in vertical position in the sediments, is probably to be met by the observation that the shells of the recent Nautilus, which is a bottom-crawler, and even those of the Spirula which lives sessile at considerable depth, rise after the death of the animals to the surface and become pseudo-planktonic, a fact fully established by Walther (Zeitschrift der Deutsch. Geol. Gesellsch., 1897, 49: 258). The cause of this phenomenon, if the chamber during life time of the animal were filled with water, is not quite apparent, but perhaps is to be sought in the decay of the organic tissues; and it is to be inferred that the same took place with the extinct cephalopods and to some extent also with the shells of Orthoceras. The writer has seen exposed near Valcour, Lake Champlain, on large surfaces of Beekmantown limestone, which were clearly shore-deposits of that period, the tangled growth

of sea-weeds, between which run, in approximately east-westerly direction, narrow tide channels filled with black mud and a rich mass of gastropods and large straight cephalopod shells, The latter lay parallel to the direction of the channel and were clearly wedged in or drifted in together with the gastropods, which often lay piled up behind the Orthoceras shells.

There is further to be accounted for the existence of forms like Orthoceras truncatus Münster. This was in the habit of regularly breaking off the cone of its shell and then mending the mutilated apex with a plug. It can not have been sessile, but as the crawling, more or less involute forms are supposed to have developed from the sessile orthoceratites it must be conceded that these truncate orthoceratites were possibly forms which had finally taken the step of detaching themselves but instead of rolling up, discarded the unwieldy cones. The slightly curved Oncoceratites probably stand in close connection to these forms and are the result of further adaptation to the crawling mode of life. At the same time appears the fact that these species preferred to discard entirely the greater part of the conch instead of rolling it up, to argue for the supposition that the cameræ were of little or in fact of no use as hydrostatic apparatus and indeed but a hindrance to movement.

Our supposition that the orthoceratites may probably have planted themselves in the oceanic deposits, does not appear to agree well with Jaekel's conclusion that this was the mode of existence of nautiloids with contracted apertures as Gomphoceras and Phragmoceras, as the latter with their breviconic, rapidly expanding cones would seem to have adapted themselves to an entirely different habit of life as the orthoceratites. But it is here to be considered that the breviconic form of the shells may well have been the result of further complication of their structure as Dr. Clarke suggested to me, namely of the contraction of the aperture, which invited a lateral expansion of the animal, thus producing low and broad living chambers and cameræ. Furthermore the broad low shell of these forms is obviously well adapted to squatting upon the sea bottom. From the contraction of the aperture and the resulting constriction of the arm-bases, Hyatt concludes that the arms could not have been powerful enough in these forms for a crawling habit and that they hence were either sessile or swimming.

The strong constriction of the aperture, which points to forms like Lepadidæ and Balanidæ, combats the latter possibility. Sessility remains then alone the alternative. In regard to this habit I would like to add that our considerable New York fauna suggests the occurrence of two different methods of sessility of these organisms. We have, on one hand the rather large turbinate types of Gomphoceras, which find their principal development in the Schoharie grit, Hamilton shale and also in the Goniatite limestone. These clearly give the impression of having been planted vertically in the mud with their apical portions, the expanded portion resting on the surface of the bottom. On the other hand, however, we have lately become acquainted with a relatively rich fauna of small, slightly curved, in general talon-like types of Poterioceras in the Guelph beds of New York, and similar forms are known from the Chazy and Trenton limestones. These are obtained from beds which are coralligenous. They are characterized by their relatively small size, their tendency to assume curved and bilateral symmetric shape, and above all, the fact of their frequently discarding or losing the greater part of the conch, so that only a few of the last cameræ are found adhering to the living chamber. These peculiarities appear to point to a different mode of life and, in connection with their occurrence in the coralligenous beds, suggest that they may have lived in the cavities of the reefs themselves, just as living cephalopods hide themselves in rocky caves.

ANNOTATIONS.

By John M. Clarke.

Essential to professor Jaekel's conception of fixation in Orthoceras, seems to be the assumption of a conchiolin protoconch. The existence of this structure in such form can not be regarded as demonstrated. Professor Hyatt was not prepared even after a close study of the putative calcified Orthoceras protoconch described by the writer, to grant that it appertained to that genus. Confirmatory evidence was at that time lacking,—it was the only recorded instance of an Orthoceras-like shell in which the protoconch was retained, and the object could not be generically interpreted from its intrinsic characters. The presumption, in view of the examples brought

forward by Barrande and Hyatt in which only a cicatrix was shown, was against its orthoceran character. The writer's interpretation of it, however, finds corroboration now in the recent discovery by Pocta of many young orthoceran shells bearing calcified protoconchs. Whether we regard the genus Bactrites as nautiloid or ammonoid, it is a longicone like Orthoceras and that it had a well developed, fully calcified protoconch, has been abundantly shown (Branco, the writer), indeed specimens with protoconch attached are no longer uncommon occurrences. Whatever mode of life is postulated of Orthoceras must be equally true of Bactrites and it is clear that the latter could never have been fixed at its apex. A calcified protoconch at once demolishes the strange structure with which Jaekel would prop up the Orthoceras. I am disposed to believe there is reason to infer that while in early and primitive forms of Orthoceras the protoconch may have been wholly of conchiolin, in later forms, through acceleration or other causes, calcification might have set in at an initial stage. The suggestion that Orthoceras buried itself vertically in the mud, impresses me as intelligible and helpful; that it was affixed at the sea-bottom seems unessential and unlikely.

As the occurrence of vertical Orthoceras in the Oneonta sandstone at Oxford, N. Y., which has been twice referred to in the foregoing, constitutes the only observed illustration of the presumed normal attitude of these shells, I may say that the interpretation suggested by Dr. Ruedemann is in approximate agreement with the other conditions wherewith the occurrence is involved. These bodies are highly abundant in a certain stratum, which lies at the outer edge of a Devonic fresh or brackish water lagoon where land drainage was received in great quantity. An excessive outflow at time of freshet, carrying the fresh waters beyond their proper boundary, probably would have killed outright a settlement of Orthoceras buried in the littoral muds without, and have washed into close proximity to them remains of Amnigenia and terrestrial plants such as characterize the true Oneonta deposits. Whether such an outflow would have swept away from the Orthoceras settlement all mobile forms of marine life may be a question for determination, but it is true that as yet no other trace of marine life has been found in this bed.

THE CENTRAL OHIO NATURAL GAS FIELDS.*

By J. A. Bownocker, Columbus, O.

PLATE XIV.

Introduction.

Four fairly distinct reservoirs of gas have been discovered in central Ohio. Geographically, however, they are closely related, and the same is true geologically, and for these reasons all will be considered together. In other words the several reservoirs will be regarded merely as parts of one large field.

Locations and Areas.

At the present time the gas fields consist of two parts, one known as Sugar Grove, and the other as Homer. Between these, two additional reservoirs have been discovered, but both have long been exhausted; one lay at Thurston, Fairfield county, and the other around Newark, Licking county.

By far the most important reservoir is in Fairfield and Hocking counties and is known as the Sugar Grove. It includes parts of the following townships in Fairfield,—Berne, Pleasant, Rush Creek and Madison, but in the last two, however, very few wells are found. In Hocking county lying south of Fairfield, the producing territory includes parts of Good Hope, Laurel, and Marion townships. The length of this field as developed in 1902 was sixteen miles, and the maximum width eleven miles. The longer axis extends north and south.

The Homer field, as developed in 1902, included parts of Burlington, Bennington, Washington and McKean townships, Licking county; and Milford, Miller and Morgan townships, Knox county.

Lying between these two reservoirs were those at Thurston and Newark, but as already stated both have been abandoned. By reference to the map accompanying this article it will be seen that the several tracts named form parts of a belt extending north and south. The length of this is about sixty miles.

History and Development.

No other event in the history of Ohio has so stimulated the search for underground wealth as did the discovery of natural

* Published by permission of Edward Orton, Jr., State Geologist.

HARRISON

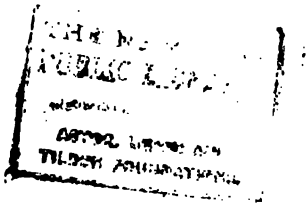
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ASTOR, LENOX AND
TILDEN FOUNDATIONS



gas at Findlay in 1884. From that as a center drilling has radiated in all directions until every county in the state has been tested; in some the wells may be counted by scores, in others by hundreds, and in a few by thousands. From the areal standpoint these tests have in the main produced negative results only, and yet they form the basis of one of the state's principal sources of wealth. The Findlay discovery was followed a year later by that of oil in the Trenton limestone, and in 1887 by natural gas at Lancaster.

The first step towards testing the rocks in the vicinity of the town just named was taken in December, 1885, when the Lancaster Natural Gas Company was organized. In the following May the first well was begun, the objective stratum being the Trenton limestone. On February 1st of the ensuing year (1887) gas was found at a depth of 1957 feet; and though the well was small, the mere presence of the desired fuel was sufficient to secure further tests. Two additional wells were drilled that year in the same general vicinity, and with similar results. Preparations were at once made to pipe the town; and the new fuel finding immediate favor, the company was not able to meet the demands, owing principally to the expense of laying the necessary mains.

All the wells drilled thus far were small, so that the outlook for the territory was not bright. In fact during the winter of 1888-9 the supply had so far decreased that it did not meet the moderate demands then existing. The situation changed suddenly, however, in February, 1889, when a new well, "The Mithoff" was completed. This had an open flow of 12,000,000 cubic feet per day, changing at once the character of the territory. Another famous well was completed that year. It was located on the county fair grounds and had an initial open flow of 10,000,000 cubic feet per day. A line from this well was laid around the race track that fall and "By this means the track was lighted up at night as never was race track lighted before, and the trials of speed went forward under this wanton illumination. The idea was novel and the scene unique and brilliant, but the waste was barbaric all the same."*

In the spring of 1888 the city, by authority of the Legislature, bought the existing natural gas plant, extended the mains,

* *Geol. Sur. of Ohio*, First Ann. Rep. (1890), p. 237.

drilled new wells, and in other ways prepared to profit by the discovery which the enterprise of a few citizens had made possible. The next thing was to find a market for the new fuel, and "the strange folly that seems bound up in a municipal corporation when it obtains a good supply of gas, that it must find some one who can use the fuel up in the largest way and most rapidly to whom to give it, without money and without price broke out also in Lancaster. An ill-omened arch bearing the illumined inscription 'Free gas to manufacturers' spans the main street of the town at the railroad crossing."* The efforts of the city to secure factories through the offer of free gas were not successful as they had been in northwestern Ohio, and consequently Lancaster did not experience the boom that Findlay and adjacent places enjoyed. The results, however, were good, the city being better in every material way than before the discovery.

Newark was another of the towns stimulated by the work at Findlay. The first well, drilled probably in 1885, did not reach the Lancaster gas rock, but in October of the following year another well was begun which after considerable delay reached the gas rock, the depth being 2385 feet. A small flow only of gas was found, but it was sufficient to secure further exploration. Accordingly the third well was soon completed but with similar results. Other wells followed in quick succession, and by 1889 the supply was regarded sufficient to warrant piping the town. The wells, however, were small, the best producing only about 1,000,000 cubic feet per day, and in the winter of 1889-90 the supply was not adequate to meet the demands.† An effort was made to meet the difficulty by drilling new wells, but this was only partially successful. The Newark reservoir cannot be regarded as having contributed notably to the fuel supply of the state.

In the spring of 1888 a well was drilled at the village of Thurston, which lies between Lancaster and Newark, the result being a small producer of gas. The second well located one mile farther east, had an initial production of 7,000,000 cubic feet in twenty-four hours and a rock pressure of 700 pounds to the square inch. This started the excitement, and

* *Ibid*, p. 236.

† Vol. vi, pp. 370-1; also First Ann. Rep. (1890), pp. 237-240.

by the summer of 1889 sufficient gas had been secured to warrant laying a line to Columbus. Rapid progress was made so that in January, 1890, that city was enjoying natural gas for the first time. The supply decreased so rapidly, however, that by the ensuing November the company was compelled to discontinue furnishing the fuel to factories, and by January 15th, 1891, to cut off the city entirely. After that date very little gas was taken from the Thurston field. The number of wells drilled in the vicinity of that village numbered nearly thirty. The short life of this reservoir resulted from the small area and the heavy demands made on it. The quantity of gas contained in any rock is limited, and the duration of the supply is determined by the demand; double the latter and the life of the field is cut in two. The length of the territory was three and one-half miles, and the width one-half mile.

In February, 1891, a well was completed on the Zink farm, about two miles north of Lancaster, and a production of 6,000,000 cubic feet of gas per day secured. Naturally other wells were soon begun, and nearly all were successes. In May, 1891, the volume secured was such that Columbus was again supplied, and since that date the city has enjoyed an uninterrupted supply of the finest fuel in the world.

The next step in the development of the Central Ohio fields was taken September 3, 1893, when a well was completed on the Meesbarger farm about three miles northeast of Sugar Grove. This was a large producer, and the energy of the driller was at once turned to that territory. Work has been continuous from that date, with the result that the producing territory has been extended into four townships in Fairfield county and three in Hocking. At first the fuel was supplied to nearby towns, such as Logan and Lancaster, but as the territory was developed and its wealth disclosed, other corporations entered the field and the fuel was piped to more distant places. In this way the demands have become enormous. Five large companies and three smaller ones are shipping the fuel as fast as it can be secured. The territory supplied is well illustrated by naming the cities and the towns that are the principal consumers: in northern and northwestern Ohio there is Toledo, Bowling Green, Fostoria, Fremont, Clyde, Bellevue, Norwalk, Chicago Junction, Carey, Upper Sandusky, Tiffin,

Bucyrus, Marion, Mt. Gilead, Mansfield, Galion, Crestline, Shelby, and Ashland; in the central part of the state, Columbus, Delaware, Westerville, Newark, Mt. Vernon, Zanesville, Lancaster, and Circleville; in the southern and southeastern parts, Logan, Nelsonville, Athens, and Chillicothe; in western Ohio, Dayton, Springfield, Urbana, Piqua, Troy, and Sidney.

The original rock pressure of this field was about 900 pounds to the square inch, but under the heavy calls made the pressure has become much less. This however varies from place to place; in the fall of 1902 it had decreased to 100 pounds around Sugar Grove, but at other points it was larger, rising occasionally to 600 pounds. This low pressure was not sufficient to drive the gas through the lines to distant points, and in 1900 the companies began the construction of powerful compressors. Later midway stations were built, so at the present time the rock pressure is strongly re-enforced, and in this manner the lines are kept filled. Probably the largest well in this territory had an initial open flow at the rate of 12,000,000 cubic feet per day; but at the present time wells of one-third that size are looked upon with much satisfaction. Persons familiar with the field estimated that the average quantity of gas per well put into the lines in 1902 was about 250,000 cubic feet per day. It is safe to say that during the year just mentioned at least 60,000,000 cubic feet of gas have been taken on the average from the Sugar Grove field every twenty-four hours. This territory has already passed the zenith, and unless extensions are found its production will decrease rapidly.

One more paragraph and the historical side of this question will be brought to a close. In July, 1900, a well was completed near the village of Homer in the northern part of Licking county, and began producing about 1,500,000 cubic feet of gas per day. Other wells were drilled within the following year, and with similar results. Late in the autumn of 1901 and early in 1902 larger producers were secured, and consequently during the latter year work was very active. Nearly all the wells were successes, and ranged in size from about 1,000,000 to 4,000,000 cubic feet per day, the rock pressure varying ordinarily from 700 to 800 pounds per square inch. The greater number of these were in Burlington township, Licking county.

Early in the fall of 1902 a well was completed on the

Hunter farm in section six of Miller township, Knox county. This had an initial open flow of between 11,000,000 and 12,000,000 cubic feet per day. In December following a well was completed on the Miller farm located on the northern part of the same section, the result being a 9,000,000 cubic foot well. Early in January, 1903, a well was completed on the Beinhower farm in the southwest corner of the same section, and a 11,000,000 cubic foot producer secured. Just north of these giants a number of producers, ranging from 4,000,000 to 6,000,000 cubic feet have been completed. These wells radically change the character of the field.

While the territory has not yet been tested sufficiently to demonstrate its lasting quality, the indications are that it will equal the best yet found in the Clinton sand. Several of the largest companies operating in the Sugar Grove field have entered this territory, the result being that a number of the principal cities in the central part of the state are using fuel from the Homer field. This much can be said for the territory at present,—the acreage is large, rock pressure high, gas rock continuous, and salt-water absent below the Berea grit. It will supplement the supply of fuel received from Sugar Grove, and may do much more.

Geology of the Fields.

As has already been stated the geological relations in the several reservoirs are in the main similar, and consequently may be considered together. Where differences occur specific mention will be made. The gas rock was first classified by Dr. Orton with the Clinton, but later he appears to have been in doubt concerning the accuracy of this determination. From numerous well records, and from samples of drillings collected and examined by the writer, it appears that the gas rock lies near the base of the Clinton formation, being separated from the underlying Medina by a few feet of dark slate. This will be made clear in the following pages:—

Well Records. The succession of strata below drainage is shown by the following record of Federal well No. 1, located four miles below Lancaster in the old canal bed.

		Thickness of formation.	Depth to bottom of formation.
Drive pipe (ten inch)		54 feet	54 feet.
Shales		91 "	145 "
White sand, with water		20 "	165 "
Sandy shale		135 "	300 "
Gray shale		90 "	390 "
Sunbury (Berea) shale		52 "	442 "
Berea grit (cased with 8¼ inch pipe)		25 "	467 "
Bedford shale (red)		103 "	570 "
Ohio shales..	black shale	560 "	1130 "
	white shale	142 "	1272 "
Corniferous, Lower Helderberg and Niagara limestone,		687 "	1959 "
Top at 1272 feet			
Salt-water at 1407 "			
Salt-water at 1682 "			
Base of limestone 1959 "			
1944 feet of 6¾ inch casing			
Clinton shales and sandstone	White slate	66 "	2025 "
	Red rock	18 "	2043 "
	Limestone shell	8 "	2051 "
	Blue slate, break	4 "	2055 "
	Shales and limestones	15 "	2070 "
	Blue slate	5 "	2075 "
	Clinton sand top at 2075 feet.		
	Bottom of well at 2088 feet.		

Following is the record of the lower part of a well on the Bauer farm, two miles west of Sugar Grove. Samples of drillings below the Niagara were collected by the writer:

Corniferous, Lower Helderberg and Niagara limestones, top at		1430 feet.
bottom at		2132 "
Clinton shales and sandstone	Shales, light chocolate colored. Little lime	36 "
	Shales, green and chocolate colored, the latter fossiliferous. Some lime	31 "
	Shales, green and chocolate colored. Much lime	37 "
	Gas sand at	2237 "

The following skeleton record of the McNichols well, twenty-five miles south of Sugar Grove in Jackson township, Vinton county is of interest because it shows the thickness of both the Clinton and the Medina:

Berea grit, top at	888	feet.
bottom at	942	"
730 feet of 8⅓ inch casing.		
942 feet of 6¼ inch casing.		
Corniferous Lower Helderberg and		
Niagara limestones, top at	1735	"
bottom at	2390	"
Clinton, top at	2390	"
bottom at	2460	"
Medina, hard above, but very soft below, top at	2460	"
2554 feet of 5 3/16 inch casing. bottom	2560	"
Cincinnati series, top at	2560	"
bottom of well	2860	"

In the Sugar Grove territory the great limestones (Corniferous, Lower Helderberg and Niagara) are charged with salt-water, which sometimes completely fills the well. The formation is unbroken, except in the lower fifty feet, where it becomes shaly, so that the transition to the Clinton is not abrupt, and yet it is easily recognized by the driller.

Lastly, there is given a skeleton record of a well on the Dunlap farm near Homer in Burlington township, Licking county.

Drive pipe (8 inch)	307	feet.
Berea grit, bottom at	556	"
566 feet of 6⅝ inch casing.		
Corniferous, Lower Helderberg and		
Niagara limestones, top at	1310	"
bottom	2074	"
Pink limestone and shales, top at	2074	"
bottom	2187	"
Clinton sand, top at	2187	"
bottom	2216	"
Bottom of well at	2222	"

The most interesting feature of this part of the field in comparison with that around Sugar Grove is the absence of water below the Berea grit. As shown in the record just given only one string of casing is used, and that extends merely to the base of the Berea. This greatly diminishes the cost of the wells, and also the chances of water forcing its way down into the gas sand.

The Clinton formation.—This outcrops in the southwestern corner of the state. Its area there is very small, forming a mere band around the Cincinnati series, but owing to a tendency to form an escarpment with the underlying formation

the Clinton is quite conspicuous. The formation in that part of the state is essentially a crystalline limestone. This is usually delicately colored and is often highly fossiliferous. At places it is a building stone of high grade, but uneven bedding has been an obstacle to its use for this purpose. In one or two counties it is burned for lime, furnishing a product of excellent quality. The rock is calcareous in composition, becoming in some places the purest rock of this type in Ohio. The following is an analysis of the limestone near Osborn, Green county:*

Carbonate of lime	97.14 per cent
Carbonate of magnesia	1.21 " "
Alumina and oxide of iron	.41 " "
Silicious matter	.70 " "
	99.46 " "

Occasionally in the part of the state under consideration, a thin bed of clay, called by Foerste the Beavertown marl forms the top of the Clinton, and at other points a lean deposit of Clinton ore occupies the same relative position. The earliest geological reports of the state spoke of the rock carrying the odor of petroleum, and about forty years ago wells with this substance in view were drilled in it. The result, however, was total failure.†

Under cover in the northwestern part of the state the composition of the rock changes, resembling very closely that of the overlying Niagara. This is well shown in the following analysis of the Clinton from near Bowling Green:‡

Carbonate of lime	49.19 per cent.
Carbonate of magnesia	40.31 " "
Insoluble residue	7.76 " "

At Fremont, Sandusky county, the formation has been the source of a small reservoir of gas;§ and occasionally it has yielded a small quantity of oil or gas in adjacent counties.

In central Ohio the formation presents a complete change. The limestone has disappeared, and there are found in its place shales of various colors and compositions, and usually an intercalated bed of sandstone. The shales contain a noticeable

* *Geol. Sur. of Ohio*, vol. vi, p. 728.

† *Second An. Rep. Geol. Sur. of Ohio* (1838), p. 225; also vol. iii, (1878), p. 407.

‡ *Geol. of Ohio*, vol. vi, p. 728.

§ *Ibid.*, pp. 183-9.

quantity of carbonate of lime, this being most abundant in the thirty-five feet above the gas rock. Well drillings strongly indicate that the green and chocolate colored shales are interstratified with calcareous ones.

The gas rock is a light colored sandstone of moderate grain. It drills hard, suggesting that the parts are well cemented. The thickness of the stratum is not definitely known; especially is this true in the Sugar Grove field, where it has rarely been drilled through. The maximum reported from that territory is thirty-four feet, and the average is perhaps one-half of that. Around Homer the sand is drilled through; five wells selected at random showing thicknesses of 10, 28, 8, 12 and 18 feet, an average of 15 feet.

Below the gas sand there is found a thin bed of shales commonly ranging from ten to thirty-five feet in thickness. This has a dark color and is succeeded below by dark red shales. Since work nearly always stops before the latter are reached, or when they have been penetrated a few feet, thus making certain that the horizon of the gas sand has been passed, data bearing on their thickness are meager. The record of the McNichols well, previously given, credits 100 feet to the formation. The top of this red rock is regarded as the summit of the Medina.

Life of Wells.—This depends on several factors, such as nature of gas rock, closed pressure, initial flow, acreage per well, rapidity with which the gas is used, salt water, care taken of wells, etc. The short life of the Thurston field has already been noted. That of the territory around Newark was longer because the demands made on the wells were not so heavy. The following table was compiled from wells in the Sugar Grove field. It shows the original rock-pressure and open flow, the decrease of these, and to some extent the life of the wells. The data are taken from wells that have been practically in continuous use. Doubtless records could be secured from this teritory that would show a greater period of production than any wells contained in this table.

TABLE SHOWING THE INITIAL ROCK PRESSURE AND OPEN FLOW, AND THE DECREASE OF THESE IN WELLS OF THE SUGAR GROVE FIELD.

Name of Well.	When Drilled.	Rock pressure, per square inch.	Open flow per 24 hrs., cubic feet.	Rock pressure, April 1, 1901.	Open flow, April 1, 1901.	Rock pressure, Sept. 1, 1902.	Thickness of sand, feet.	When abandoned.
Berry No. 1.....	Oct., 1897...	785	7,161,000	0	0	0	18+	July, 1899.
Conrad No. 1...	Oct., 1897...	900	4,570,350	190	2,260,000	0	14+	Nov. 18, 1901.
Blazer No. 1.....	Oct., 1897...	740	9,000,000	170	3,500,000	0	?	Feb. 4, 1902.
Berry No. 2.....	Nov., 1897..	740	7,151,500	150	1,746,000	0	13+	June 5, 1901.
Lutz No. 1.....	Nov., 1897..	890	3,212,500	230	2,154,300	170	?	Still prod. Sept., 1902.
Kestler No. 2 ...	Nov., 1899..	500	8,758,000	240	.....	120	15+	" " " "
Ream No. 1.....	April, 1898..	790	7,163,000	205	3,162,800	125	7+	" " " "
Harman No. 1..	Jan., 1899...	650	9,969,000	220	.....	?	?	" " " "
Wooden No. 2..	Sept., 1898..	700	8,374,000	0	0	0	18+	Abandoned Feb., 1901.
Shull No. 1.....	July, 1899...	640	8,870,500	300	5,530,000	150	18+	Still prod. Sept., 1902.
Edwards No. 4.	Feb., 1900...	410	3,000,000	230	?	175	20+	" " " "
Kestler No. 1...	Dec., 1897...	800	6,451,000	225	3,571,000	100	13+	" " " "
Starner No. 1...	July, 1901...	420	7,500,000	?	?	120	24	" " " "
Brandan No. 1.	July, 1901...	425	2,000,000	?	?	250	19	" " " "
Dupler No. 1....	Nov., 1901..	580	7,128,000	?	?	210	26	" " " "

The table shows plainly the short life of wells in the best territory, where care is taken to prolong their lives. Since the rock pressure of the field is now much lower than it was a few years ago, it follows that wells drilled hereafter will be much shorter lived than those sunk formerly.

Salt Water.—Operators and drillers are almost a unit in reporting the gas sand free from water. However, the great limestones lying above the Clinton rock are charged with brine in the Sugar Grove field, and this is a constant source of danger, for unless the packer fits tightly the water crowds into the sand, causing serious trouble, and sometimes ruins the well. Around Homer, as has already been stated, no water is found below the Berea grit, and consequently the danger is much smaller.

Rock Structure.—The strata in the Sugar Grove field have been considered by some on *a priori* grounds to form an anticline, and by others a terrace. Neither, however, appears to be correct. On a line running almost due east and west through Sugar Grove, the rock dips to the east nearly 260 feet in less than six miles, an average of forty-five feet per mile, barometer measurement.

This shows neither an arch nor terrace extending through the territory north and south. Further, at the village Amanda, eleven miles west of Sugar Grove, the Clinton rock lies 600 feet higher than it does at the last named village. This excludes a possible suggestion that the gas belt may lie in the eastern slope of an arch, as several reservoirs of oil and gas are known to do in eastern Ohio.

From Lancaster the rock dips southeast more rapidly than the bed of the Hocking river slopes, as is shown by the increasing depth of the wells in the valley of this stream. This excludes the idea of an east and west arch or terrace.

The large reservoir known as the Sugar Grove, may be regarded as consisting of several small but contiguous ones. This is well illustrated by changes in rock pressure. Thus the rock pressure at Lancaster has long been nil, while the wells on the Zink farm, two miles north of that town, which were drilled in 1891, still have a pressure of from 500 to 600 pounds per square inch. Around Sugar Grove the pressure has dropped to 100 pounds, but a few miles away it is several times that

figure. Farther south in Hocking county similar conditions are found. It appears that these small reservoirs are separated by strata that are practically impermeable, and consequently that one may be drawn on or even exhausted without materially affecting the adjacent reservoir. This is a marked contrast with the results experienced in the Trenton limestone territory of northwestern Ohio.

Composition of the Gas.

Below is given an analysis of gas from the Thurston field, the work having been done by professor C. C. Howard of Starling Medical College.

Carbon dioxide	.25 per cent.
Oxygen	.15 " "
Olefines	.30 " "
Carbon monoxide	.15 " "
Nitrogen	8.12 " "
Hydrogen	.55 " "
Paraffines (Marsh gas etc.)	90.48 " "

For comparison there is given an analysis, made by the same chemist, of natural gas from the Trenton limestone at Findlay.*

Marsh gas	92.61 per cent.
Olefiant gas	.30 " "
Hydrogen	2.18 " "
Nitrogen	3.61 " "
Oxygen	.34 " "
Carbonic acid	.26 " "
Carbonic oxide	.50 " "
Sulphuretted hydrogen	.20 " "

Search for the Clinton in Eastern Ohio.

Many wells have been drilled within the past few years in the eastern part of the state, especially in the counties bordering on the Ohio river, for an oil or gas rock below the Berea grit. The object has been to find one of the deeper sands known in Pennsylvania and West Virginia, and if not successful in this to proceed until the Clinton is reached.

These trials have disclosed an interesting fact with reference to the thickness of the Ohio shales, lying between the Berea grit and the Corniferous limestone. Thus at Lancaster these shales have a thickness of 702 feet, near New Lexington,

† Vol. vi., p. 136.

eighteen miles farther east, 1160 feet, and at McConnellsville, forty miles east of Lancaster, 1712 feet. This is an average increase of twenty-five feet per mile, and if this rate should continue until the Ohio river is reached, it would mean a thickness of over 2,500 feet for the formation. This is in harmony with a test made farther north near East Liverpool where these shales were penetrated to a depth of 2,600 feet without reaching their base. It is apparent from this fact that it is practically useless to attempt to develop an oil or gas field in the Clinton in eastern Ohio; and further it may now be regarded as having been demonstrated by the drill that when the Berea grit has been passed in this territory all hope of finding an oil or gas rock is gone.

STRUCTURE OF THE SOUTHERN PORTION OF THE KLAMATH MOUNTAINS, CALIFORNIA.

By Oscar H. Hershey, Berkeley, California.

In the Klamath region, the observation of strikes and dips, unless followed industriously for a long period and over a broad extent of territory, is a waste of time, as it leads to but one conclusion, namely that the entire region has been broken up by small irregular folds and faults which mask the true character of the structure. In certain areas the dips will be prevailingly in one direction, generally easterly, and give the observer the impression that the formation as a whole is inclined in that direction, whereas the easterly dips are due solely to a vast number of small, easterly tilted fault blocks.

The only satisfactory method of obtaining a correct appreciation of the structure in a broad sense, which the writer has found available in the Klamath region, is the persistent following of contacts between different formations. After several years devoted to that kind of work, one acquires the habit of forming mental pictures of the individual formations as single great masses of unbroken rock, disregarding the innumerable minor dislocations. It is of this major structure that I propose to treat in this paper.

The present degree of deformation of the rocks of the Klamath region is the result of movements at different periods

of geologic time. At about the opening of the Quaternary era, the territory was warped into a series of broad, comparatively low arches and domes. *Earlier, but yet at a time post-Cretaceous in age, the same region had been acted on by orogenic activity, the result being a series of structurally enclosed basins, separated by broad ridges which were high in comparison with those formed at the opening of the Quaternary era.† The products of these two periods of orogenic activity were characteristically different from that of an earlier period which appears to have affected the region at about the close of Jurassic time. The Early Tertiary and Early Quaternary deformations were like those which have been shown to have operated on the Southern Appalachian province in post-Cretaceous times,‡ while the first post-Jurassic disturbance of the Klamath region was essentially of what is known as the Appalachian type, being characterized by great folds and faults, with axes extending for hundreds of miles in a certain direction common to the system. The broader structural features of the Klamath region are principally due to this post-Jurassic disturbance and my remarks in the succeeding pages will treat of it chiefly.

The pre-Cretaceous stratified formations involved in the Klamath mountains west of the Sacramento river consist of three series, a highly metamorphic series of schists, supposed to be of pre-Cambrian age, probably Algonkian, possibly Archæan; a series of less highly metamorphosed slates, quartzites, limestones and cherts, of an age ranging from early in the Devonian to the close of the Carboniferous period; and a Mesozoic series also altered by metamorphic action, but less intensely than the Paleozoic series.§ The first series consists chiefly of the Abrams mica schist, which is supposed to have an exposed thickness of about 1000 feet; and overlying it, the Salmon hornblende schist, known to be at least 2500 feet thick. Probably the real thickness of these formations is much greater.

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* "Neocene Deposits of the Klamath Region, California," *Journal of Geology*, vol. x, No. 4, May-June, 1902.

† "The Significance of Certain Cretaceous Outliers in the Klamath Region, California," *Am. Jour. of Sci.*, vol. xiv, July, 1902.

‡ "Geomorphology of the Southern Appalachians," *National Geographic Magazine*, vol. vi, pp. 63-126.

§ "Metamorphic Formations of Northwestern California," AMERICAN GEOLOGIST, vol. xxvii, April, 1901.

The Paleozoic series is estimated to be not less than 5000 feet thick and seems to represent continuous deposition in a broad sea basin. The Mesozoic series is divided sharply into two formations, of which the lower was composed of volcanic materials such as andesite and rhyolite lavas and tuffs, intruded by dikes of diorite, diabase and rhyolite porphyry, all now altered to rocks abounding in sericite, chlorite and epidote. This complex of volcanic materials, the Clear Creek series, is overlaid unconformably by several thousand feet in thickness of alternating black slates and blue quartzites, with conglomerates locally developed, the whole taken together as the Bragdon formation, which is supposed to be of about the same age as the Mariposa formation in the Sierra Nevada region and hence late Jurassic. The total thickness of the stratified formations so far as known is about 12,000 feet, but probably a more thorough study of the region will show the real thickness to be several times as great.

East of the Sacramento river, Diller, Smith and others have shown that there is there developed a Mesozoic series of slates, limestone and sandstones of late Triassic and early and middle Jurassic age, which seems to be totally unrepresented west of the Sacramento river, except in a few small remnants near Redding, its place in Trinity county being occupied by an erosion interval. This region east of the Sacramento river and a narrow strip west of that stream have lately been thoroughly investigated by Diller in mapping the Redding Quadrangle of the United States Geologic Atlas, and its geology is hardly within the province of this paper.

The distribution and relations of the stratified formations of the Klamath region south of the Klamath river, are now sufficiently well known to make the following history of their deposition reasonably certain: The original sediments of the Abrams mica schist were laid down on the sea bottom with comparative uniformity of character and thickness over the entire area. Upon them were deposited the supposed volcanic ashes which have been metamorphosed into the Salmon hornblende schist. Apparently this also extended beyond the territory now under discussion. Then these two formations were metamorphosed, uplifted and eroded. The denudation in places cut away the hornblende schist and exposed the mica schist.

A geologic map of the territory at the close of this period of erosion would probably have displayed an irregular assortment of patches of hornblende schist in a ground work of mica schist.

The Paleozoic series was deposited in a comparatively deep sea and extended far beyond the Klamath province. Upon its uplift at the close of the Carboniferous period, it was deeply eroded, so that the earliest Mesozoic formation rests indiscriminately upon its earlier and later members. However, there is no reason to believe that it was anywhere completely cut through and the underlying schists laid bare, except possibly in one very limited area near Lowden's ranch in Trinity county, and even there the phenomenon of contact between the Mesozoic rocks and the schists may be the result of faulting.

The Clear Creek volcanic series was spread as a sheet of varying thickness (probably between limits of 200 and 2000 feet) over the entire territory south of the Klamath river, except possibly not in the vicinity of the present Scott and Shasta valleys. It was then exposed to erosion in the country west of the Sacramento river and leveled off, but it seems not to have been cut through at any place except probably along the northwestern border of the province, in the vicinity of the present station of Delta.

A study of the Bragdon formation has developed a curious bit of geologic history of northern California. It was undoubtedly laid down in a sheet gradually thinning to the westward over the entire region of the Klamath river and west of the Sacramento river. It extends only a short distance east of the latter river in the vicinity of Delta and Elmore stations and in this region contains considerable beds of comparatively coarse conglomerate, which wedge out westward by becoming thinner and finer in texture. The pebbles are composed chiefly of the cherts of the Paleozoic series.

Now, these Paleozoic chert pebbles could not have been derived in any of the territory from the Trinity mountain westward as, everywhere in that region, the Clear Creek volcanic series intervenes between the two slate series. Near Delta and Elmore, on the Sacramento river, the volcanic series seems to be thin and discontinuous from erosion preceding the Bragdon epoch, a fact indicated not alone by my own observation

but also by evidence recently communicated to me by Mr. Diller and in that region may be found the source of the Paleozoic chert in the Bragdon conglomerates. The explanation seems to be that the eastern shore-line of the Bragdon body of water was just a little eastward from the site of the present Sacramento river, while northeastward from it erosion was effective on a land whose surface formations were largely the slates, limestones and cherts of the Paleozoic series.

The absence of marine fossils and the presence of some plant remains in the Bragdon formation may indicate that it was not laid down in the open sea, but in an inland body of water, perhaps brackish in character.

The fact which I have endeavored to bring out by this brief resumé of a portion of the geologic history of the southern portion of the Klamath region is that at the close of the Bragdon epoch of deposition and just preceding the orogenic activity whose products I am about to describe, the territory was underlaid by four practically continuous sheets of rock, a foundation of schists, a thick layer of Paleozoic rocks, a thin layer of volcanic materials and a thicker layer of Mesozoic sediments. It is by following the contacts between these four layers that the structure of the region may be truly and readily determined.

Considered first as to its broader features only, the southern portion of the Klamath region may be described as consisting of a central ridge of schists, bordered on the west by a great, unsymmetrical geosyncline, and on the east by the western limb of another great geosyncline. The first geosyncline is limited on the west by another belt of schist, chiefly the Abrams mica schist, which forms the South Fork mountain and is prolonged northwestward to and probably across the Klamath river near Wichiper. The sandstones of the Coast Range region adjoin this schist belt on the west. Mr. Diller has informed me that toward the north, approaching the Klamath river, long, narrow belts of schist alternate with narrow belts of sandstone, the latter dipping eastward as though going under the schists. This apparent anomaly is evidently due to a series of faults. It is further evident that the Coast Range formations have buried the western portion of the schist belt which latter may extend, immediately under the sandstone, far toward the coast.

The eastern schist belt emerges from beneath the Cretaceous sandstones and shales in the Sacramento valley west of Ono, with a width of eight miles and gradually increases as it advances northward to a maximum of about twelve miles west of Scott valley. Southward from the Trinity river, the pre-Paleozoic area is occupied chiefly by the Abrams mica schist, the hornblende schist being confined to narrow strips, but northward from the Trinity river, the hornblende schist spreads out and finally nearly excludes the mica schist as in the valley of the South Fork of the Salmon river. Still farther north, in the mountains west of Scott valley, the mica schist has again asserted its supremacy.

The structure within the schist belt is somewhat obscure, but it is certain that there is no sharp folding of the schists as in the areas of newer and less rigid formations. At one time I thought I saw evidences of two narrow anticlines in the schist area south of the Trinity river, but now I am less confident of that conclusion. It appears to me rather that the schists have been elevated to unequal hights in irregular areas without the formation of any clearly anticlinal or other symmetrical types of structure. Mapping, considered in relation to the present topography, is developing the situation and shape of some of the structurally depressed and elevated areas of the schists and little more can be said about them at present.

The space between the two schist belts has a width south of the Trinity river of about twenty-four miles and northward in approaching the Klamath river increases to about thirty five miles. It is occupied mainly by the Paleozoic series, although somewhat west of the center there is a narrow belt of Mesozoic rocks, consisting of the Clear Creek volcanic series and the Bragdon slate series. The Paleozoic series is difficult of separation into its constituent members because of its comparative uniformity of character throughout, but the presence of Upper Carboniferous fossils just east of the Mesozoic belt as found by the writer at Patterson's on New river in western Trinity county, and by Mr. James Storrs* (an assistant of Mr. Diller) near Harrison gulch in western Shasta county, makes it evident that the Mesozoic series rests upon the upper members of the Paleozoic series.

* *Bulletin of the U. S. Geol. Survey*, No. 196, Series F, Geography, 31, p. 64.

Along the eastern border, near the schist contact, the Paleozoic strata resemble the known Devonian on the opposite side of the schist belt as in Shasta county, particularly in their extremely cherty constitution, and while no fossils have been found to fix positively the presence of Devonian rocks in the western belt, it is safe to assert that in traveling from the eastern schist belt westward, one traverses progressively (except for a minor folding) higher members of the Paleozoic series until the Mesozoic rocks are reached. The argument that I wish to draw from this premise is that practically the entire thickness of the Paleozoic rocks is present under the Mesozoic belt, and that along the axis of this belt, where the Bragdon slate is at least 1000 feet thick, and the Clear Creek volcanic series probably of like thickness, the base of the Paleozoic rocks where they rest on the schists, must be at least 7000 feet beneath the present surface; probably it is much deeper. Where the Trinity river crosses the axis of the trough, near Hawkin's Bar, the schists must be depressed to not less than 5500 feet below sea-level. There is no reason for believing that the axis of the trough rises materially to the northward or southward within the limits of the area under discussion.

The schists in the belt on the east rise to an altitude of 8500 feet above sea-level and those on the west reach nearly or quite 6000 feet. It is very likely that were the base of the Paleozoic rocks restored to its position over the crests of these two schist ridges, it would be far above any elevation now reached by these schists. Therefore, any calculation of the depth of the trough based upon the present highest points of the bordering schist ridges will be a perfectly safe one and probably fall far short of the reality.

Generalizing broadly, I shall say that this western geosyncline of the southern Klamath region is a trough from thirty-five miles wide in the south to fifty miles wide in the north, and 11,500 feet deep relative to its western edge and 14,000 feet deep relative to its eastern edge.

The eastern geosyncline is even broader and perhaps deeper than that just defined. Only its western half properly belongs to the Klamath region and extends from the crest of the eastern schist ridge of Trinity county to the Big Bend region of Shasta county. It includes all that portion of the Klamath

mountains lying east of the Sacramento river. As already intimated, the present writer does not desire to go at length into the structure of that territory as it has been thoroughly studied by Diller whose report on it is not yet issued, but certain general facts have long been known to the geologic public and may be detailed as follows: A considerable area lying just east of the schist belt, in eastern Trinity and western Shasta counties, is mainly occupied by the Clear Creek volcanic series and the Bragdon slate series. Small isolated areas of Devonian strata appear in this territory in a way to indicate that this Mesozoic series is immediately underlaid over a considerable extent by Devonian rocks. These Devonian rocks come out in force from under the Mesozoic rocks east of the Sacramento river. The same Devonian belt extends northward and westward to Scott valley in Siskiyou county, where it adjoins the schist area.

As it will not seriously affect the argument, it is proper to disregard the Mesozoic rocks lying on the Devonian strata in eastern Trinity and western Shasta counties and consider the schist belt as bounded, structurally on the east by a Devonian belt. This is followed eastward by a Carboniferous belt, then by Triassic strata (the Pit shales and the Hosselkus limestone), and these by Jurassic strata (the Bend shales and the Morrison sandstone), the latter carrying us quite to the easternmost point of the Klamath mountain system.

The eastern limb of this geosyncline is mostly buried under the lavas and tuffs of the Lassen volcanic region, but at the northern end of the Sierra Nevada region we may have a suggestion of it in the presence, as mapped by Diller in the Lassen Peak Folio of the U. S. Geologic Atlas, of Silurian strata followed on the west by Devonian and this latter by a broad belt chiefly Carboniferous. Strata of Carboniferous and Jura-trias ages occurring in positions not conforming to the above ideal westward succession weaken the argument and I give it as little more than a suggestion.

The structural features which have been described as characterizing the southern portion of the Klamath region are undoubtedly not confined to that area. Their extension northward will be a matter of future observation. Southward these two geosynclines must underlie the Cretaceous rocks of the

Sacramento valley for a long distance, probably several hundred miles. Southward from a line drawn through Weaverville, the course is southeast, in conformity with the strike of the stratified rocks of the Sierra Nevada region. Probably the western geosyncline is completely buried under the Sacramento valley and the western limb of the other trough is barely represented, if at all, along the extreme western border of the Sierra Nevada region where Calaveras rocks appear west of Jurassic strata.

Northward from a line drawn through Weaverville, the strata strike north and finally bend toward the northeast, and when the geosynclines pass beyond the Klamath region they are striking toward the interior of the continent.

Superimposed on the geosynclines are structural features of the second order such as anticlines, synclines, monoclines and faults. These are especially apparent in the western trough where the Paleozoic and Mesozoic strata have been more or less closely and regularly folded in a manner similar to the Appalachian region. The folding of the Paleozoic rocks is somewhat difficult to work out because of the uniformity of the series, but certain belts of limestone, and in southern Trinity county, narrow belts of quartzyte, pass up and down the slopes of the mountains and are apparently repeated three or four times within a half dozen miles in a way to indicate a rather close folding of the series. The Mesozoic rocks of Trinity county lent themselves to this folding action much more readily than did the Paleozoic rocks, and in the Clear Creek and Bragdon area south of Hay Fork village, there are at least three synclinal folds occupied by the Bragdon slate, separated by anticlines in the axes of which the Clear Creek volcanic series outcrops, all comprised within a space of two miles. These folds are persistent along the strike for twelve or fifteen miles.

In the western Paleozoic area, long narrow belts of the Clear Creek volcanic series occur folded down into the slates. Four miles below Cecilville, in the valley of the South Fork of the Salmon river, there is clear evidence that there has been a complete overturn of a limited area so that limestone, slate and chert of the Paleozoic series rest upon tuffs of the Clear Creek series. The contact is the original one, showing a nonconformity, but now upside down.

The structure of the Mesozoic area of eastern Trinity and western Shasta counties has been partially described by me in several former papers* and little new material can be added. The area as mapped has a length from north to south of about forty miles and a maximum width of about thirty miles with a probable average of twenty miles. It occupies a basin-shaped depression in the surface of the Devonian rocks, which latter, however, do not come to the surface along its western and northwestern borders, partly because of faulting and partly because of the intrusion of vast masses of peridotite along that line. The axis of the basin lies considerably northwest of the center, has a course approximately north-northeast to south-southeast and occupies the position nearly of the present summit of the Trinity mountain. In this central and deeper portion of the basin, the Bragdon slate outcrops without interruption over extensive areas, but nearly all around the borders, it has been upturned, eroded and the volcanic series laid bare.

The northwestern one-third of the basin is characterized by the development of a system of beautiful anticlines. They strike east-west with a tendency to bend northeastward in entering Shasta from Trinity county. The Trinity river between Trinity Center and Eastman gulch, a distance of eighteen miles, traverses about ten of these anticlines. The intensity of the folding reaches a maximum a few miles south of Bragdon where the elevation of the axis of the anticline may be 2000 feet above the same strata in the axes of the bordering synclines. The strata are closely appressed, so that at and near the river-level, the contacts are vertical and in places slightly overturned. From this point both northward and southward there is noticeable a progressive decrease in the amplitude of the folding vertically, and lengthening of the rolls, until the system dies out in comparatively gentle undulations.

If we follow the crest of a given anticline, using the contact between the volcanic series and the overlying black slates as our datum plane, we will find it rising and falling in a series of gentle undulations. Also, we will find frequent small faults, with throws of 10 to 100 feet, with a consequent tilting of the

* "Origin and Age of Certain Gold 'Pocket' Deposits in Northern California," AMER. GEOL., vol. xxiv, July, 1899.
" Metamorphic Formations of Northwestern California," AMER. GEOL., vol. xxvii, April, 1901.

fault blocks between. The combination of all these structural features has given rise to such a complexity of local dips that anyone crossing the country on one of the stage roads is likely to arrive at almost any kind of conclusion in regard to the general structure of the area.

Subsequent to the completion of the Clear Creek volcanic series and apparently also subsequent to the deposition of the Bragdon slates, much of the Klamath region was invaded by huge batholiths and dikes of peridotyte, since largely altered into serpentine. The largest area of serpentine occurring in the southern portion of the Klamath region occupies the extreme northeastern part of Trinity county and adjoining sections of Siskiyou and Shasta counties. It has a length in a direction from northeast to southwest of about forty-five miles and a width between five and twenty miles, but within this area there are other intrusives. It has chiefly invaded the Devonian belt east of the central schist ridge, but also extends into the latter and forms the northwest boundary of the Mesozoic belt.

Next there were intruded batholiths of gabbro and pyroxenyte, mainly within the serpentine areas. Another change in the underlying magma resulted in the intrusion of granite batholiths. These rise in the serpentine areas and in the belts of schists, Paleozoic and Mesozoic slates. Their outcrops usually form oval or elliptical areas, square miles in extent, several exceeding a score.

The intrusion of such great masses of eruptive material into the sedimentary rocks must have had some effect on the structure of the latter, but as yet I have failed to observe any strong evidences of an extensive displacement of the strata. The granite masses appear to be in the form of huge columns, rising vertically through the other rocks. In only one instance, namely, that of Mt. Courtney at the head of the South Fork of the Salmon river, do the strata seem to have been distinctly thrust up around a granite batholith. Here the schists have been upturned, so that a narrow belt of Abrams mica schist completely surrounds the granite. In all other cases observed, the granite seems to have simply replaced part of the formations intruded. Of course, in the vicinity of the contact there was more or less disturbance of the stratification by the intruded granite, but no such disturbance of the areal geology

by forcing the surrounding strata into new positions as to be accurately and appreciably represented on an ordinary geological map. The strata which once held the position now occupied by the granite are gone. They either sank into the granite mass and were absorbed or they were raised up vertically and removed by erosion.

Contact metamorphic zones as markedly distinct from the regional metamorphism of the surrounding country are not numerous in the Klamath region. The only really prominent one which I have observed was called to my attention by Dr. H. W. Fairbanks. The largest granite batholith, extending from near Igo in Shasta county through the Trinity range to near Lewiston in Trinity county, is bounded on the northeast by the Bragdon series of slates, quartzytes and conglomerates. Adjoining the granite, the sedimentary rocks have been converted into a mica schist resembling the old schists of the pre-Paleozoic series. The metamorphic action is apparent to the unaided eye for several hundred feet distant from the granite and by means of a small hand microscope is yet clearly distinguishable at the distance of several hundred yards.

Now, nothing of the kind occurs around the granite batholiths where they were intruded into formations which were already more highly metamorphosed than the Bragdon slates now are. When the granite rises through the hornblende schist, the border is characterized by breccias of angular fragments of schist embedded in the granite. There is not the least evidence of fusion along the contact, but every indication of violent fracture of hard rocks. The strata removed were not fused in place and as the physical conditions which forced up these columns of melted rock preclude the probability of the strata having sank deep into the earth, I consider it practically a certainty that they were raised vertically, blown out by volcanic force and have long since disappeared by erosion.

As the peridotyte intrusions were on a grander scale than those of granitic rocks, we will more surely expect in connection with them to find evidence of the lateral compression of the surrounding strata. Perhaps the folding of the Mesozoic rocks in the Trinity Mountain area in a system which is at variance with other folds of the region may have been due to compression by the vast mass of melted peridotyte rising on

the north. However, opposed to this idea are the facts that close to the border of the serpentine area, the folding is slight, and that the apparent large batholith of serpentine is probably a combination of many smaller batholiths so that perhaps only a small part of it may have been in fusion at one time and thus incapable of exerting much more compressive strain on the surrounding rocks than did the granite batholiths.

The serpentine areas interrupt the continuity of the belts of stratified rocks, but do not seriously displace them. From the high specific gravity of the peridotyte, it is not likely that the disappearance of the strata replaced was brought about by sinking, and of fusion in place there is no evidence. Probably they were lifted to such a hight that erosion has since removed them.

In denying, in the preceding paragraph, that there is any evidence in the Klamath region of fusion, by the heat of the intruded magmas, of those portions of the stratified rocks which once occupied the position now held by that portion of the intrusives which is above the stream-level of the region, I do not wish to convey the impression that there is no evidence of fusion and absorption of the same sedimentary series at greater depth, but simply that erosion has not yet penetrated to the zone in which this occurred.

The injection into the comparatively pliable sedimentary strata of material yielding such rigid masses of rock as granite, gabbro and peridotyte would be expected to have a marked effect on a subsequent system of folding of the region. No such effect is apparent in the southern portion of the Klamath region, and I conclude that the folding was virtually completed before the intrusion of these batholiths. The granite almost invariably rises as vertical columns. Following the intrusion of the granite there were systems of dikes injected into the rocks. The majority of these dikes approximate very closely to the vertical. It is impossible to say what deformation may have affected the large serpentine areas, but the small serpentine dikes which are very plentiful in the Paleozoic area west of the central schist belt, remain vertical. Had all these batholiths and dikes been involved in the folding of the sedimentary rocks, they should be inclined at various angles, not a few being conspicuously near the horizontal.

Nearly all the contacts between important formations in the Klamath region, where observed, are faulted. Most of these faults are of small throw, not exceeding several hundred feet, and are not worth considering. But there are evidences of several faults of great magnitude and probably more will be discovered in the future.

In a former paper* I called attention to two in the Upper Coffee creek region which I denominated, respectively, the Lawrence and Keating faults. At that time I was laboring under the delusion that the serpentine involved by these supposed faults is an altered sedimentary, probably underlying the entire region except where gabbro rose from under it, and the recognition of the faults was partly based on this supposition. But now that I have become aware of the true character of the serpentine as an altered intrusive, I see that the original argument was weak, but I none the less firmly believe in the existence of these faults. They trend north to south, parallel with each other and about one-half mile apart. They have been traced for ten miles. In the case of each, the upthrow is on the east and amounts to between 1000 and 2000 feet. Mica and hornblende schists and serpentine are involved, and the latter has been displaced in such a way as to make it certain that the faulting occurred subsequent to the intrusion of peridotyte. Both are thrust faults and might be considered due to the same comprehensive strain as produced the folding of the region were it not for the evidence which places the peridotyte intrusion between the two. The Lawrence fault runs so close to a granite batholith without any displacement as to suggest that it is of later age. At the same time, acid dikes were intruded along the line of both faults so persistently as to make it evident that the faulting preceded them. The intrusion of these acid dikes followed closely upon the intrusion of the granite batholiths. Therefore, if my observations have been accurate, the faulting was due to a comprehensive strain exerted closely succeeding the intrusion of granite batholiths and long subsequent to the general folding of the region.

In the paper mentioned above, I have also defined the "Trinity Center Fault." This is undoubtedly a fact as the actual fault plane between the serpentine on the west and the

* "Gold Bearing Lodes of the Sierra Costa Mountains in California," AMER. GEOL., vol. xxv, February, 1900.

Clear Creek volcanic series on the east has been seen, but upon recognition of the serpentine as an altered intrusive, the evidence of the importance (because of great throw) of this fault becomes very weak. Where the same fault is due south of the Trinity river, the Bragdon slate is in direct contact with the schists and I am inclined to believe that it is a faulted contact with a considerable but indeterminable throw.

I have long suspected that the profoundest fault of the territory may occur along the contact between the eastern schist belt and the Paleozoic belt west of it. This line runs straight for many miles. Usually the contact goes down from the mountain tops to the valley bottoms nearly or quite vertically; indeed, just south of the South Fork of the Salmon river the contact may be inclined toward the schist area. The hornblende schist and the mica schist as bordering the Paleozoic rocks change places several times. So far the evidence is in favor of faulting.

North of the King Solomon mine, in Siskiyou county, the Paleozoic series has, next to the schists, a formation of squeezed and crushed, fine conglomerate which appears to be the "basal conglomerate" of this series. This basal formation could not here be in contact with the schists unless practically an original or unfaulted contact. At the La Grange hydraulic mine near Junction City in Trinity county, the Paleozoic slates pass over on to the hornblende schists and in places rest upon it horizontally and with such an irregular contact as to preclude the idea of faulting. The nature of this line separating the schists from the Paleozoic strata is a matter of considerable interest and should receive attention in the near future.

Where I examined the contact between the Paleozoic slates and the schists of the western belt, in the valley of the South Fork of Trinity river, near the mouth of Rattlesnake creek, it is apparently not a faulted one. The surface of the schists seems to have been hummocky and the Paleozoic sediments accumulated first in the depressions. The slates dip northeasterly at a high angle and the contact is consequently sinuous on a small scale.

The joint planes constitute another structural form present to an interesting degree in the Klamath region, but the study of them has not yet progressed to the point of generalization.

Berkeley, Cal., Jan. 13, 1903.

SOME RESULTS OF THE LATE MINNESOTA GEOLOGICAL SURVEY.*

By N. H. WINCHELL, Minneapolis.

This topic has been chosen at the suggestion of the chairman of the Section (Prof. W. M. Davis), but with reluctance. The results of the survey have been published fully. Owing, however, to the volume of literature devoted to the Minnesota Survey, it is believed that a condensed enumeration of the chief scientific and economical results of that survey may be of use.

(1). At the commencement of the survey, the rocks that are now included in the Upper Cambrian were embraced under the two terms "Lower Magnesian limestone" and "Potsdam sandstone." It soon became apparent that the former embraced three parts, which had been unknown to D. D. Owen and his predecessors. Two of these were individually designated Shakopee limestone, and New Richmond sandstone (a term adopted from the Wisconsin survey) and the term Lower Magnesian (since rejected by the Iowa Survey in favor of a new term Oneota) was restricted to the main body of the limestone exposed in the cliffs of the Mississippi between Hastings and Winona. That these two new parts do not belong in the overlying St. Peter sandstone is evident from the fact that at various places, as at Red Rock and at Shakopee. The Shakopee was included by Owen, who gave the original names, in his term Lower Magnesian limestone, while the Richmond sandstone, which lies below the Shakopee was never by him referred to as St. Peter sandstone.

The term "Potsdam sandstone" was also entirely changed from its early application in the Mississippi valley. It was found by stratigraphic studies that the Potsdam sandstone of Potsdam, New York, was represented in Minnesota by a more firm, even quartzitic, sandstone whose habit more nearly resembles the original Potsdam, and the term was applied to that. With this transfer it became necessary to apply new names to the friable white sandstones of the Mississippi valley. In descending order the parts thus named are, Jordan sandstone, St. Lawrence limestone, Dresbach sandrock, and Hinckley sandrock, with unnamed shales both above and below the Dresbach sandstone. The term St. Croix was given to these sandstones,

* Read Dec. 31, 1902, A. A. A. S., Washington, D. C.

not including the Hinckley sandstone, but extending from the top of the Jordan sandstone to the bottom of the Dresbach sandstone. These friable sandstones with their accompanying shales and limestones, constitute the Upper Cambrian, and lie non-conformably on the Potsdam which was found to be a part of the Keweenawan.

(2.) The geology of the Lower Silurian in the northwest has had a diversified history. On making a careful and detailed examination, both stratigraphical and paleontological, in which Messrs. Ulrich, Schuchert and Scofield were the chief colaborers, it was found that, while the limestones and shales should be, as customarily, included in the Trenton and Hudson River groups, the Galena limestone is the stratigraphic equivalent of the Trenton proper, and that the stratum which had specifically been known as Trenton limestone, as that at the falls of St. Anthony, is in a lower position and should be denominated Stones River [or Birdseye] and Black River limestones, the latter overlying. Based on the prevalent characteristic fossils each of these and the Trenton proper, were subdivided into three parts. The Hudson River formation was identified and divided into Utica and Richmond. In the progress of the Lower Silurian investigations a large number of new species were discovered and described.

(3.) The extent of the Cretaceous was found to be greater than had been supposed. It was found on the summits of the granite range in northeastern Minnesota, known as the Giant's range, at points where the Mesabi iron ore is mined. It is known to extend nearly as far east as the falls of St. Anthony, occurs in Goodhue county and it probably once covered the Mississippi valley if not that of lake Superior, lapping over into Wisconsin and Illinois.

(4.) The early Minnesota reports are the first which in America recognized the duality of the Ice-age, based on the occurrence of interglacial deposits. The measurement of the time involved in the recession of the falls of St. Anthony was the first demonstration of the recentness of the last ice epoch.* The formation of glacial lakes about the ice border when the slope of the country was toward the ice, the origin of kames (now called eskers), the superglacial position of the drift while being transported, especially in proximity to the ice margin,

* Dr. B Andrews, of Chicago, had, however, reached a similar result based on the dunes and beaches of lake Michigan.

now well-known elements in Pleistocene geology, were new conclusions reached by the Minnesota Survey. The existence and cause of lake Agassiz was stated in the first annual report.

(5.) Owing to the divergence of the strike of the two important iron-bearing formations in northern Minnesota it was observed that there were two iron horizons, thus separating the Mesabi range stratigraphically from the Vermilion. This observation was continued into Wisconsin and Michigan by a visit to those states, and the same duality was pointed out in the iron regions of those states and was announced for the first time in the Minnesota report for 1888. This grand distinction having been recognized it required only the application of detailed field observation to complete the elucidation of the stratigraphy of the iron ores. The distribution of the iron ores of the lake Superior district has been wrought out on this basis. It has since been discovered that there is still a third iron horizon in northeastern Minnesota, not mentioning the titanic iron ore of the gabbro. It is the Upper Keewatin, the others being in the Lower Keewatin and the Taconic.

(6.) It was the Minnesota Survey that separated the Archean into two non-conformable parts, viz. the Upper and Lower Keewatin, with a great basal conglomerate between them. Others had announced a basal conglomerate at the base of the "Huronian," but it appears that by Huronian, in this instance, was meant the upper iron ore beds, which are not included in the Archean, but belong to the Taconic (Animikie). Such non-conformity also occurs in Minnesota, and is well known at the base of the Mesabi iron range rocks.

(7.) It was the Minnesota Survey that detected the oldest known rock in the lake Superior region, and placed it at the bottom of the Archean. It is the greenstones that were named Kawishiwin, the bottom rocks of the Keewatin, the supposed earliest crust of the globe.

(8.) The Minnesota Survey also reached the conclusion that the great quartzyte formation which cuts quite a figure in the geology of Wisconsin and Minnesota is non-conformable upon the Animikie, and is a member of the fragmented beds of the Keweenawan. This has been named Sioux quartzyte, Barraboo quartzyte and New Ulm quartzyte. It is that which contains the red pipestone (catlinyte) in southwestern Min-

nesota. It is the western representative of the Potsdam sandstone, of Potsdam, N. Y. The light-colored friable sandstones, both in New York and in the Mississippi valley, lie higher, and are allied to the Calciferous, lately called Beekmantown. The eruptive disturbances which immediately followed this sandstone in the lake Superior region, causing the widespread nonconformity of the lately friable sandstones, were wanting in the Adirondack region. Hence the difficulty of separating this quartzyte from those later sandstones in the northern part of New York state. This quartzyte seems to be the representative of the Middle Cambrian, as the Beekmantown is of the Upper Cambrian.

(9.) The final conclusion of the Minnesota Survey as to the origin of the Mesabi iron ores refers them to a greensand, which has been altered, affording iron ore by concentration of the iron in certain favorable positions. Cotemporary with this alteration was a concentration of silica, and this was increased by oceanic precipitation. The original greensand was found to become pebbles, and to increase into angular masses that were neither sand nor pebbles, but rather breccia. These breccia masses have at first an amorphous crystalline texture and grade into a form of the iron-bearing rock which was named taconyte, and the whole was referred to volcanic action, being different forms of suddenly cooled volcanic glass and rhyolyte, broken and distributed by beach action. While this volcanic debris was undergoing this transformation great quantities of silica were set free from the glass, but this silica immediately saturated the debris producing spotted jasperoid taconyte and sedimentary jaspilyte. (No. 2 below.)

Having reached this result on the Mesabi range it opened the door to the understanding of the iron ores of the Vermilion range, and at once the rhyolitic forms and all the igneous associations of those ores with basic igneous rock, were elucidated, thus confirming Wadsworth's idea of the igneous origin of the jaspilytes of the Marquette region—rather the igneous origin of the rock which later was changed into jaspilyte.

Here a few words of caution are necessary. There are three rocks which may be called jaspilyte, and have been so called.

(1.) The rock above described, the result of silicification of basic rhyolytes and obsidian.

(2.) The siliceous rock resembling the last but evidently resulting from oceanic chemical precipitation, forming long parallel bands intersheeted with greenstone debris and with other sediments, and grading into ordinary slate, or graywacke or into a siliceous greenstone. These bands are not wavy nor curled, nor structurally suggestive of lava flows.

(3.) A detrital debris resulting from the destruction of either of the foregoing. When compacted, and especially when metamorphosed, such secondary jasper bands are sometimes hard to distinguish from primary jaspilyte.

All of these forms of jaspilyte may be so charged with iron oxide as to constitute iron ore.

(10.) After prolonged field examination the Minnesota Survey reached the conclusion that the granites of the Archean grade into gneiss, the gneiss into micaceous gneiss and mica schist, and finally into less and less metamorphic rocks that show a plain fragmental structure and sedimentary origin. There was found no exception amongst the Archean granites. The granites are of two dates of formation, one at the close of the Lower Keewatin and one at the close, or after the close, of the Upper Keewatin. A later granite, associated with the gabbro, and grading into it, is of the Keweenawan, and another is still later. Hence it was inferred that the Archean granites did not spring from a deep source, but are a surface product of metamorphism carried to the extreme of fusion, on clastic materials that were later than the basal greenstones. Adventitiously they form intrusions in some of the later (and especially into the clastic) greenstones, but they are not known to penetrate the oldest greenstones. Tentatively the alkaline and the acid siliceous elements in these early sediments were supposed to have been derived from the atmosphere, as the basal crust could not have afforded them.

(11.) In the same manner the gabbro, which becomes acid and grades into svenyte, was derived from the metamorphism and fusion of the greenstones with their elastic variations. Diabase was found to pass insensibly into gabbro, but on the other hand it is also certain that it was the original form of all the igneous greenstones, and that it must have had a deep seated source, and has still a deep seated source.

These belts of intensest metamorphism, whether productive of granite or of gabbro, have a parallelism with each other, and with the northwestern rim of the great synclinorium of the basin of lake Superior, marking successive continental folds, in harmony with a system which continued through Archean and Taconic time, and even into the Upper Cambrian.

(12). In the progress of the survey the mineralogy of the state was considerably extended, there having been added fifty-six species to the known minerals of the state. The greater part of these were identified in the region of the crystalline rocks.

Of the economic and educational results the following are worthy of mention:

(1.) In the settlement of the prairie regions of Minnesota, which are based largely on a uniform but very thick deposit of drift clay, the immigrant usually depended for domestic water supply on shallow wells, not usually over thenty-five feet in depth. In some of these wells a sufficient supply of good water was found in thin gravel or sand layers; but in by far the larger number the supply was scant. Such scant supply was derived by seepage from the till. Had it not become contaminated by artificial causes it would have been sufficient. But, in the absence of stone and brick for walling up their wells the settlers frequently resorted to pine planks which they obtained from the lumber markets. These they set vertically so as to enclose the well reservoir completely. Typhoid fever and enteric disorders became abnormally frequent and fatal, so much so that capitalists who were interested in the settlement of the lands of the state were fearful that the foulness of the usual well water would effectually retard the development of the agricultural lands. The health officers of the state shared in this suppressed alarm.

After a careful examination of the conditions it was discovered that the difficulty arose almost solely from the use of pine planking in curbing the new wells. The prevailing alkaline quality of the water seemed to hasten the decay of the pitch of the pine, and, uniting with the resultant acids, not only produced offensive odors but favored the propagation of those germs that are formed in stagnant water. The waters were found to be wholesome when fresh from the earth, although

very hard, and sometimes alkaline. This result was widely published. Iron or stone or earthern piping was substituted at once for pine planking, and the sickness and alarm rapidly subsided. This is one of the most important and immediate of the beneficial results of the survey.

(2.) Of the economic resources whose development can be traced to the initial research of the survey only two will here be mentioned.

(a) The excellent qualities of the Hinckley (Kettle River) sandstone were discovered by the testing of the building stones of the state by the geological survey. At that time there was not a quarry operative in the state on that stone. It was immediately introduced into the markets of St. Paul and Minneapolis, and is now recognized as an excellent building stone, and is largely employed throughout the state. (b) The existence and position of the Mesabi iron range were pointed out by the geological survey, as distinct from the Vermilion range, in 1884. Explorations which followed this publication were successful in the discovery of the first important deposit on that range. Since then the Mesabi range has developed into the greatest iron-producing district in the world. Throughout its early development the geological survey was in constant contact with the workings of the various explorers, and watched the progress of geological as well as economic evolution.

(c) But, notwithstanding the scientific discoveries of the Minnesota Survey, and over and above all its aid rendered to economic interests, it is probable that the most valuable service it has rendered to geology consists in this:—the illustration it has given of the establishment of a state geological survey by a state legislature and the entrusting of the same to the state's university. It is not an uncommon thing now, but when the Minnesota Survey was submitted to the Board of Regents of the State University, it was a novel and unheard of proceeding, and its progress was scrutinized closely by the authorities of other states. The original law was carried out without a single change. The plan of progress and of the report, which was adopted the first year of the survey, was faithfully carried out to completion and without a single interruption, lasting a period of twenty-eight years, i.e. from 1872 to 1900.

In 1884 I had the pleasure and honor to read to Section E, as its chairman, a vice-presidental address, the burden of which was to show the varied interpretations that had been given to the Archean and Huronian rocks of the Northwest, and to attempt to tabulate the parts, as then understood, in a systematic scheme. The conclusion of that address was a statement that utter confusion reigned, and that no order or classification could be presented. Today that statement would not be true. After prolonged and careful field examination and minute work in the laboratory the order of the main parts of the Archean is recognized, and unanimously adopted by all the geologists who are at present concerned in Archean geology in the lake Superior region. The only differences now extant pertain to the naming of the parts, and the comparative rank which the various features of Archean geology should maintain in the general scheme. There are also many differences of detail as to origin and relationship of the various rocks, but a great advance has been made in the establishment of a recognized general scheme. The next twenty-five years may result in as marked progress in the settlement of these minor questions.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Esquisse stratigraphique et petrographique du Bassin de la Tafna (Algérie). LOUIS GENTIL. 5 plates (3 geological charts). 536pp. Algiers, 1902. Adolph Jourdan.

Previous to this publication, 211 papers or memoirs had been published relating to Algeria, as listed by the author, most of them in the French language, but the earliest was that Dr. Shaw in English, in 1743. The province was occupied by the French about 1830.

The oldest rocks of the region described may be Archean, but, although they are styled "primitive" by the author, their characters depart considerably from well known Archean. They occupy but a small geographic area, but they are found in the form of bombs thrown out by volcanic action of recent date, also in the area of the Triassic gypsum. They are essentially garnetiferous gneiss with sillimanite. The oldest sedimentary rock of ascertained age is Permian and its age is expressed doubtfully. The most of the region described and mapped is occupied by Cretaceous and Tertiary rocks and their eruptives, and by later eruptives. The valley of the Tafna is in the extreme western part of Algiers. Near the western margin is the granite of Nedroma which

is overlain by a Permain conglomerate "and is hence Primary" (p. 97). The author assigns to the Permian certain andesitic eruptions in the vicinity of Miliana, and elsewhere, analogous to the porphyritic eruptions of several places in Europe.

The sedimentary rocks are described in detail, and are illustrated by numerous figures showing their structural relations; and the accompanying fossils are listed. The author describes the singular and apparently numerous blocks of igneous rocks, and isolated bosses, which are scattered in the sedimentary areas.

"The acid rocks within the Triassic area are everywhere granites, composed of muscovite, amphibole, garnet of a light color, very acid feldspar varying from oligoclase-albite to albite; but these species result at least partly from secondary actions: in fact there exist all possible stages between the two feldspathic extremes. One is in the presence of the phenomena of albitization of calci-sodic plagioclases, as in the case of the granites of Pelvoux studied by Termier.* By the side of these plagioclases thus transformed, are deposited, in the openings and fissures of the rock albite crystals that are evidently secondary. This albitization is produced indifferently in the types with micas, and in those, more basic, with amphibole.

These granites have frequently undergone crushing and lamination which have profoundly modified their structure. (Letourneux, Bel Abbès, etc.); they have thus acquired a pseudoporphyritic structure, presenting beautiful instances of the cataclastic structure. Further, it is worthy of note that the albitization of the calci-sodic feldspars began, perhaps, before the mechanical reconstruction of the minerals of the rock, but that it was prolonged, without any doubt, after the influence of orogenic action. Finally, dynamometamorphism of these granites was not accompanied by the phenomena of the recrystallization of their elements as has been described for many regions."

It might be supposed, perhaps, that the albitization of the feldspars, noted by the author, is a species of the recrystallization to which reference is made by other petrographers.

Among the basic rocks Dr. Gentil has observed, several of those peculiarities that have been described in the Pyrenees by Lacroix.

The Tertiary and later eruptives are not described with equal care. The purpose of the author having been mainly to ascertain their extent for the construction of his geological map, and the main succession of parts.

The absence, in this volume, of a suitable presentation of the magmatic and chemical relations of the igneous rocks described is explained by the author by the statement that such investigations are reserved for a future memoir. This second publication will be welcomed by all geologists and especially by petrographers, for Dr. Gentil, who is a native of Algiers, has not only spent much time in the field studies and in the laboratory work, but has laid a foundation for a profound discussion of some of the questions which agitate at present the petrographers of the world. N. H. W.

* *Comptes Rendus*, 124, pp. 317-320.

Ellensburg (Washington) Folio. By GEORGE OTIS SMITH. (Geol. Atlas of the U. S., folio No. 86, 1903.)

This district is in south central Washington on the border between the eastern slope of the Cascade mountains and the western part of the great plain of the Columbia. The rocks are mainly volcanic, consisting largely of two series of basals (called the Yakima and the Wenas basalts of Neocene age. Later flows of andesyte, dating from the Pleistocene, occupy some of the valleys, and there is a series of fluviatile deposits which are at times interbedded with the later (Wenas) basalts. To these sediments the term Ellensburg formation is applied. The wider valleys contain deposits of Pleistocene alluvium and gravel.

One of the most interesting parts of the description of this quadrangle is Dr. Smith's explanation of the physiographic features of the district. After the deposition of the Neocene basalts and sediments the district was gently folded and eroded to a peneplain. An uplifting and gentle folding of the peneplain surface then took place, and erosion again began its work, continuing to the present day. The main stream of the district is the Yakima which flows southward near the eastern edge of the quadrangle. This river was able to maintain its course across the rising east-west folds of the last period of orogenic movement and is deeply intrenched in canyons where it crosses these ridges; the Yakima is thus regarded as an antecedent stream. The smaller streams of the district flow eastward to the Yakima and are, at least in a number of instances, confined to the axes of the synclines, which have been little eroded since the warping of the peneplain surface. These streams are thus consequent in nature, and the ridges separating them are anticlinal in structure. U. S. G.

United States Geological Survey. Chicago Folio, No. 81. WILLIAM C. ALDEN. 1902.

United States Geological Survey. Masontown-Uniontown Folio, No. 82. MARIUS R. CAMPBELL. 1902.

United States Geological Survey. Ditney Folio, No. 84. M. L. FULLER AND GEO. H. ASHLEY, 1902.

Probably there is no geological publication extant that excels these folios in the exactness of the information given, in the fullness of description, the clearness of presentation, the time and expense involved in the preparation, the excellence of the engraving and printing and the cheapness at which they are sold to the public.

The work of some of the early years of the United States Geological Survey was severely criticised, both for its lack of correct correlation and its inaccurate topography. Those faults may be ascribed to a shifty and somewhat unsystematized method of procedure, errors that are incident to any enterprise of great scope at the time of its inception. But of late these faults have been eliminated and no one seems to have the ability, if he had the disposition, to point out errors or to suggest improvements.

These are truly "final reports," constructed on the same idea, but not always on the same plan as most of the "county reports" of the state surveys, but including areas that disregard county boundaries,

usually somewhat larger than a single county, bounded by geographical meridians and parallels. The reports present, not the details of structural observation, but generalized descriptions, with references to publications where more detail can be found. In important regions, such as involve large economic interests, numerous columnar sections of the strata are given; the areas are described from every geologic point of view.

The prices of these folios, and of all other publications of the survey can be ascertained by addressing an inquiry to the Director of the survey at Washington. N. H. W.

Report on the Geology of Louisiana, containing special papers by different authors; based on the work of three field seasons, 1900, 1901 1902. GILBERT D. HARRIS, Arthur C. Veatch and Jov. A. A. Pacheco, Baton Rouge, 1902, made under the direction of the state experiment station, WILLIAM C. STUBBS, director, Pp. 288, 10 plates.

The managers of the Louisiana state experiment station have shown wisdom not only in the initiation of this survey but in the selection of geologists to make it. It is, so far as known to the writer, the first and only instance in which the necessary alliance between geology and agriculture has been recognized by the use of the funds of the "experiment station" of the state in an examination of the geological structure. It is to be hoped that the good showing that is made by Dr. Harris and his assistants will induce the state legislature to make financial provision for a continuance and extension of this survey. Previous to this report a short "preliminary report" by W. W. Clendenin has appeared, under the same auspices (1896), and Dr. Otto Lerch began the "geological and agricultural survey" in 1892. It has been interrupted because of lack of funds. N. H. W.

Notes on Cambrian Faunas, by G. F. MATTHEW, L.L.D., *with description of a new species of Metoptoma.* [Trans. Roy. Soc. Can., 2d Ser., Vol. VIII, Sec. IV, p. 93].

The principal "note" in this group of short papers is on the oboloid shells of the Cambrian system in Canada and is accompanied by a plate showing the several Oboli that have been found in this region. It is shown that there is a wide difference in the arrangement of the muscles that hold the valves together, and hence it is inferred that though similar to Obollus in form they are not closely related to the type of this genus. By a table of the Cambrian zones it is shown that all of these species except one are older than the typical *Obolus apollonis.*

The next note relates to the development in size of the inarticulate brachiopod of the basal Cambrian, showing that all the genera except Acrothyra increased the size of their valves during the progress of Cambrian time.

The third note contains a suggestion that the Upper Etcheminian fauna (basal Cambrian) invaded eastern Canada from the southwest.

The fourth note is a review of the brachiopods of the Cambrian fauna of Mt. Stephen, with the description of a new species of Metoptoma.

Bulletin of the United States Geological Survey No. 196; Topographic Development of the Klamath mountains. By JOSEPH S. DILLER.

The Klamath mountains extend north and south from the 43d parallel in Oregon, to the 40th in California. On the northwest they are separated from the coast by the Coast range of Oregon, and on the south west by the Coast range of California. The Cascade and Sierra Nevada ranges bound them on the east and in the southeast the Sacramento river has pushed its valley to their foothills.

Going as far back as Cretaceous times there is evidence that the Sierra Nevada reigon was land and that its streams were carrying sediments which were deposited on the submerged Klamath mountain region. Subsequently elevation brought the sediments above sea level and erosion removed the greater part of them. Beginning at the close of the Eocene times, there can be traced, in the Klamath mountain region, sixteen stages of development which took place during Miocene, Pliocene and Pleistocene times.

Stage 1.—In early Miocene times an uplift took place and initiated the cycle of erosion which formed the Klamath peneplain. Its record is now to be found in the flat tops of the dissected plateau which forms the Klamath mountains. Its formation was due to erosion which was subaerial toward the east and marine along the western edge. Evidence of this shore action is shown in the series of terraces which represent ancient sea beaches. They are well exposed on the Oregon coast about Port Orford where they rise in three steps, from the coastal plain to the level of the Klamath peneplain. The marine deposits of the Klamath stage are at the same horizon as the Empire beds whose age establishes the age of the peneplain as late Miocene.

Stage 2.—This period of erosion was followed by a dislocation of the Miocene deposits resulting from the erosion of the Klamath peneplain. The uplift caused little disturbance in the Klamath region but the force compressed and faulted the Miocene beds, giving them a northeasterly dip.

Stage 3.—After the elevation erosion began in the Miocene sediments and continued in the Klamath peneplain. As a result of the degradation of the Miocene beds, the Bellspring peneplain was formed. It cannot always be distinguished from the Klamath but the remnants remaining are sunfficient to establish its existence. In origin it is similar to the Klamath peneplain but erosion has reached a more advanced stage because of the softness of the Miocene rocks.

Stage 4.—The Post Bellspring uplift affected all this region both in Oregon and in California. The amount of elevation was five hundred feet along the coast with increase to two thousand feet at the crest of the range. It brought about a working of the Klamath and Bellspring peneplains and it is to these disturbances that their irregularities are due.

Stage 5.—As a result of this uplift the formation of the Sherwood peneplain was begun. Its greatest extent is about the south fork of Eel river and about Sherwood where it is five hundred feet lower than the

level of the Bellspring peneplain. Earlier valleys found in the Klamath peneplain can be traced to the Sherwood stage.

Stage 6.—Another uplift of five hundred feet closed the Sherwood stage and affected the whole Klamath mountain and Coast region. The streams began to work with renewed energy and to carve out broad valleys. These valleys of the Gaberville stage are marked features of the upland and are in strong contrast to the narrow valleys of later age; one of the best examples of these broad valleys is seen in the South Fork of the Eel river where it cuts across the Sherwood peneplain.

Stage 8.—After the Gaberville stage there was a subsidence accompanied by the formation of lakes and swamps. The tide was admitted for a long distance up the Trinity drainage, and here were deposited the fluvioestuarine sediments of the Hay Fork stage. Stage 9.—They are conglomerates, sandstones and shales containing shark's teeth and Miocene leaves. The earlier valleys carved in the Sherwood and Gaberville stages were filled with sediments and carved again after the next uplift. Stage 10.—This uplift took place in the beginning of Pliocene times and raised the land six hundred feet above the present level. The Hay Fork sediments were displaced and tilted.

Stage 11.—The Continental border stage which followed was accompanied by the removal of a large amount of material. The streams had a steep grade and the soft rocks furnished them with abundant tools. Along the coast erosion was greatest and a great thickness of Miocene deposits was removed while deep valleys were cut in the continental border plain. Stage 12.—The Post Continental subsidence of seven hundred feet brought the land below its present level, and sedimentation began on the eroded surface of the Miocene beds. The rocks of this period, Stage 13.—are known as the San Diego beds of the Battery Point stage.

Stage 14.—Subsidence continued until sea level became that of the Sherwood peneplain. The shore was terraced by marine action, At the same time, Stage 15.—an uplift began so that we find series of shore terraces capped by Pleistocene deposits. Stage 16.—The last movement has been one of subsidence which has admitted the tide into many of the rivers. The present coast from Coos bay to the mouth of the Eel river is rocky except in three places where there are coastal plains, arable and populous.

This outline of events which have shaped the present topography of the Klamath mountain region embraces the main features of Mr. Diller's paper. It has necessarily disregarded the detailed discussion of various localities, which make up a large part of the bulletin.

There is, besides, a supplement which deals with the age of the rocks in the Klamath mountains. No fossiliferous rocks older than the Devonian have been recognized but in addition to them, limestone of the Carboniferous, and slates and conglomerates of Jura-Trias and Cretaceous age have been determined. Associated with these sediments is a wide range of igneous rocks, both plutonic and volcanic. A. J.

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Ames knob, North Haven, Maine: a seaside note. (Am. Geol., vol. 31, p. 159, March, 1903.)

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Pleistocene geology of portions of Nassau county and Borough of Queens. (Bull. 48, N. Y. State Mus., pp. 617-670, Dec., 1901.)

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Studies of Eocene Mammalia in the Marsh collection, Peabody Museum. (Am. Jour. Sci., vol. 15, pp. 163-176, March, 1903.)

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PERSONAL AND SCIENTIFIC NEWS.

PROFESSORS RAPHAEL PUMPELLY AND W. M. DAVIS are about to start on a journey in western Asia to occupy four or five months. They propose to cross the Caspian sea from Baku and then take the railroad to Merv and Samarkand: the return will probably be made across the plains past the Aral sea to Orenburg in southeastern Russia.

EXTINCT BISON FROM ALASKA. Dr. J. F. Whiteaves describes in the Ottawa Naturalist four crania of Bison found in the auriferous gravels of the Klondike district from eighteen to forty-five feet below the surface. He considers that they all probably belong to Bison crassicornis of Richardson. "They are all obviously of no great antiquity, and show no traces of mineralization."

A FOSSIL MAMMOTH'S TOOTH was found recently at Given, in Manaska county, Iowa. It was still in the socket of the jaw, which was broken fortunately so as to expose the manner of insertion. It was brought to Minneapolis by Supt. A. B. Cutts of the Minneapolis and St. Louis railroad. This is in southeastern Iowa, in the valley of the Des Moines river, and in the general area of the Kansan drift.

THE GEOLOGICAL DEPARTMENT OF HARVARD UNIVERSITY offers for the following summer a field course in geology in the mountains of southwestern Colorado. Selected areas in the Needle Mountain district will be mapped, after a familiarity with the rock series has been acquired by a study of the section exposed in the Animas Canyon. The more important mining districts of the San Juan mountains will be visited. The course will begin about the first of July and continue five weeks. It will be conducted by Mr. Chas. H. White who will send a descriptive circular on application. Mr. White's address is, Rotch Building, Harvard University, Cambridge, Mass.

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AMERICAN GEOLOGIST.

VOL. XXXI. MAY, 1903. No. 5.

THE PLEISTOCENE GEOLOGY OF THE CONCANNON FARM, NEAR LANSING, KANSAS.

By N. H. WINCHELL, Minneapolis.

PLATES XV—XVIII.*

It is well known that in America for the past twenty years, as formerly in Europe, the question of the Pleistocene age of man has divided geologists and anthropologists into two antagonistic groups. The writer has not participated in this dispute, having been occupied with other lines of geological research. It is true that when he found, in 1877, the quartz chips at Little Falls he considered them pre-glacial, i.e. pre-Wisconsin. In the literature of the lengthy discussion which has arisen concerning those chips and other reported discoveries of glacial and pre-glacial man in America, will be found nothing further from his pen until 1902, when he had occasion to re-examine the Little Falls locality in the light of the results of the Minnesota Survey touching the Pleistocene geology of the state. In a chapter in "Kakabikansing," by J. V. Brower, the writer abandons his first announced opinion and refers these chips to that period when the ice was still in the central and northern part of Minnesota, while its dissolution maintained a vastly swollen river in the Mississippi valley at Little Falls. For Little Falls therefore these chips are post-Glacial, but for the state and for the general region, they date from glacial time, i.e. the closing stage of the Wisconsin epoch.

The writer therefore approached the question of the age of the Lansing skeleton in an undisturbed and judicial frame

*Plates XV and XVI are reproduced from the *American Anthropologist*, by permission of the editor of that magazine.

of mind. He made a somewhat careful and prolonged study of the environment and of the materials in which the skeleton lay. He has elsewhere given the result of that study.* He was compelled, by the evident force of the circumstances, to assign the skeleton to glacial time, and more definitely to pre-Iowan time. The materials in which the skeleton lay are of the nature of geest. The material overlying the geest is upland loess, of the mixed nature of much of the upland loess in southwestern Minnesota and in Iowa, formed contemporary with the Iowan ice-epoch, but showing some of the effects of the prevailing waters of the valley in which it was deposited. It is not the writer's intention to review the evidence on which that conclusion is based.

Since the writer reached that conclusion, however, professor Chamberlin has published in the *Journal of Geology*,† a remarkable paper on "The Geologic relations of the human relics of Lansing, Kansas," to which the writer will here give special attention. He has no desire nor interest, nor any predetermination to subserve in sustaining the pre-Glacial (pre-Wisconsin) or the post-Glacial age of the Lansing skeleton. He wishes simply to contribute somewhat to the correct interpretation of the facts bearing on the age of the Lansing skeleton.

In the discussion alluded to, by professor Chamberlin, occupying thirty-four pages of the *Journal of Geology*, the first ten pages are occupied by an illustrated introduction and an "academic statement" of the operation of scour-and-fill in river bottoms, concluding with the following:

> If excuse for this academic statement is needed it is found in its special application to the case in hand; for either action of the kind just set forth is to be accepted as an elucidation of the case, as in the preferred interpretation that follows, or it is to be shown incompetent for such elucidation before we permit ourselves to go back of this action to earlier agencies. It is a vital principle of good practice that the agencies and phenomena nearest at hand be first considered, and if the case requires, be eliminated before recourse be had to more remote agencies. This is peculiarly true when, as in this case, the agencies closest at hand have quite certainly swept away the most of a more ancient record in making their own.

The ten pages devoted to scour-and-fill, if they have no application to the case in hand, as appears to the writer, can

* Presidential address, G. S. A., Washington, 1902. *Bulletin*, vol. xiv.
† October-November, 1902, pp. 745-779. Published about December 18.

be set aside as mere academician's play, but with full acceptance of the principle quoted above; for with the non-applicability of that academic discussion there can be no application of the recent agencies—closest at hand in time—to which it refers.

Essential Points of Professor Chamberlin's Discussion.

In the course of the discussion of the special case professor Chamberlin makes the following points:

1. "The upland surface is mantled with loess and loam, the main portion of which is probably referable to the Iowan stage."

2. The tributary valley is well adjusted in its debouchure upon the bottoms of the Missouri valley.

3. The Missouri river rock-bluffs at the point where the tributary valley joins the Missouri "have been abruptly truncated by the waters of the Missouri," recently, i.e. since the Wisconsin stage, meaning thereby that the lateral erosive action of the Missouri has not only uncovered the preglacial rock bluff but has eaten further into it.

4. "The tributary valley is not occupied by a constant stream, but by periodic run-off." The channel at present is in a slightly aggraded and apparently still aggrading stage.

5. The Missouri valley is in a degradational stage, i. e. the plane of its bottoms is being sunk deeper between the bounding rock bluffs.

6. The depth of the aggradation deposit at the mouth of the tributary "is not known to me, but it is probably not many feet."

7. The lower three or four feet of the materials pierced by the tunnel "is composed mainly of limestone fragments and earthy debris, a part of the latter seeming to come from the Carboniferous beds, a part from the glacial drift or loess, and a part from the river and valley wash, in short a rather heterogeneous mixture."

8. "About three feet above the floor on the western side there is a definite layer of dark highly calcareous clay less than three inches in thickness, but it does not appear on the opposite side."

9. "Even in the inner end of the tunnel the silt [i. e. the upper part of the materials pierced by the tunnel. N. H. W.]

is notably mottled, in part irregularly and in part in bands more or less horizontal, as though controlled by stratification, though the staining is probably secondary."

10. In an offset tunnel at right angles to the original tunnel, running eastward eleven feet from the place of the adult skeleton, the "silty formation has been slightly fissured along a number of lines by tensional action and the little crevices filled with a grayish-white, soft deposit that effervesced very promptly with acid, implying calcium carbonate. Here "the vague structure lines dipped eastward irregularly."

11. The definite clayey band found near the base in the tunnel pinches out toward the west in a few feet, and does not appear on the east side. It is "very homogeneous and peculiar, as well as very fresh and calcareous."

12. Small fragments of "softened limestone" were so abundant in some parts of the walls of the open trench cut by Mr. Fowke that the walls presented a "mottling with white chalky spots made by the spade in mashing and spreading them."

13. In the walls cut by the spade the main material is a silt "somewhat closely resembling loess," but containing fragments of limestone, and shale "and other debris incompatible with a typical loess deposit," without distinct stratification or assortment, but sometimes presenting "a gravelly aspect."

14. A few drift pebbles and not a few pieces of charcoal were found in the section, also many land shells and additional bones were found by Mr. Fowke, but no unios.

15. The unio found by Prof. Williston in the roof of the tunnel, though having its valves still united, was perhaps introduced through human agency, and is not a reliable evidence of a subaqueous origin of the deposit.

16. The deposit containing the skeleton is of limited extent, formed by wash, "but not a stream deposit, nor a lake deposit nor any other form of purely subaqueous deposition. I should identify it as a typical aggradation deposit of the ravine and basal slope type when the hillside environment was Carboniferous limestone and shale mantled with loess." This idea is illustrated by fig. 13. (Fig. 1. of this paper.)

17. "The material of the one distinctly water-laid layer was probably derived from the Carboniferous shales at some

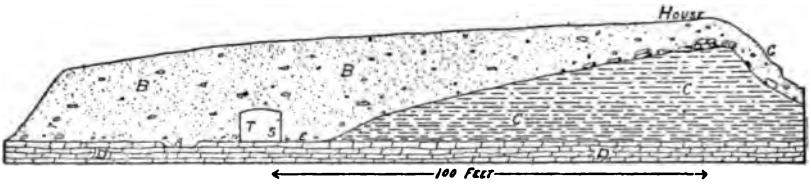


Fig. 1. Section across the tunnel, looking north.

special stage of erosion and inundation—some unusual storm and flood perhaps — and was deposited without weathering and remained undisturbed except on its borders."

18. "The main excavation of the [tributary N. H. W.] valley probably dates back to the post Kansan erosion interval, and this was perhaps preceded, and perhaps determined, by a preglacial valley."

19. "The age of the original valley and of the upland mantles does not concern us here unless these lower deposits, well down in the axis of the valley and at its junction with the great river bottoms, are surely inheritances from the older period, and not adjustment phenomena."

20. The tributary of the Missouri is narrow, steep-sided, steep-bottomed. It may be occupying an antecedent valley above its mouth but the adjustment phenomena at its mouth indicate that it is in a new channel fashioned by recent agencies.

21. It is a rare case where a new channel exactly coincides with the old channel, as when for instance in the creation of the Missouri river by many antecedent rivers—the later channels would rarely be in coincidence with the earlier [say pre-Iowan] channels, especially at their debouchures upon the valley of the Missouri.

22. The Wisconsin glacio-fluvial deposits are wanting at Concannon's; and, assuming that they have been carried away by the Missouri, there is less reason to expect that the lighter and more erosible fluvio-glacial deposits of the Iowan are preserved.

23. The human relics are in "a little relic-bearing deposit," formed by a combination of agencies. The Missouri river flowed past the site with a surface about level with the floor of the tunnel. In floodstage it rose twenty feet higher and built a floodplain as high as the "little relic-bearing deposit"

ascends, i. e. about twenty feet above the upper surface of the limestone forming the floor of the tunnel. The Missouri was diverted to the other side of its channel. There was a wash from the adjacent hills, the little tributary contributed its own flood wash, the limestone and the shale were mingled with the debris, a little drift (Kansas age) came from the region, and the human remains were buried either in the latest part of the erosive stage or earlier part of the flood-plain-building stage. This all took place since Wisconsin glaciation. "The antiquity of the burial is measured by the time occupied by the Missouri river in lowering its bottoms, two miles more or less in width, somewhere from fifteen to twenty-five feet, a very respectable antiquity, but much short of the close of the glacial invasion."

Professor Chamberlin's points separately considered.

It may be conducive to the proper appreciation of these conclusions to consider them, by number, somewhat seriatim, and to make sundry references and comparisons.

No. 1, we have no reason to call in question. We will simply remark that it necessitates the extension of the same Iowan loess into all pre-existing valleys and gorges except where it can be shown that it has been replaced by some later deposit, or has been excavated without replacement. The presumption is that it subsists in the old valleys. It is therefore the first general fact that confronts the unbiased investigator. The writer would refer here to the discussion of the upland Iowan loess and its methods of accumulation and its composition and variation by Mr. W. J. McGee in the eleventh annual Report of the United States Geological Survey,* and to the epitome recently presented in the writer's retiring address to the Geological Society of America. If one be seeking for agencies "closest at hand in time" he may ignore this great fact, but in so doing he might ignore the agencies closest at hand and most obtrusive in nature.

No. 2. There is no reason to question the present approximate adjustment of the flood-plain debris of the tributary with the flood-plain debris of the Missouri. It could hardly be otherwise with any stream that has a little flood-plain of its own at the point of debouchure upon a larger stream, what-

* *Op. cit.*, Pleistocene History of Northeastern Iowa.

ever may have been the earlier history of their relations. Such present adjustment, however, has no necessary causal relation to the past history and relations of the two streams. It is but the expression of the present moment, and, in this case, bears no significant relation, in the opinion of the writer, either to the past history of the streams or to the question under investigation. These streams, as it appears to the writer, have had a long history, with mutual adjustment relations, going back to a remote point in Pleistocene time.

3. The statement made in No. 3 may be true, but it has no bearing on the question in hand. It is, however, open to grave doubts, since it requires work of the Missouri river since Wisconsin glaciation which is in excess of what is known of river action on stratified limestones within the area of Wisconsin glaciation. This need not be discussed because of its non-importance, as will appear.

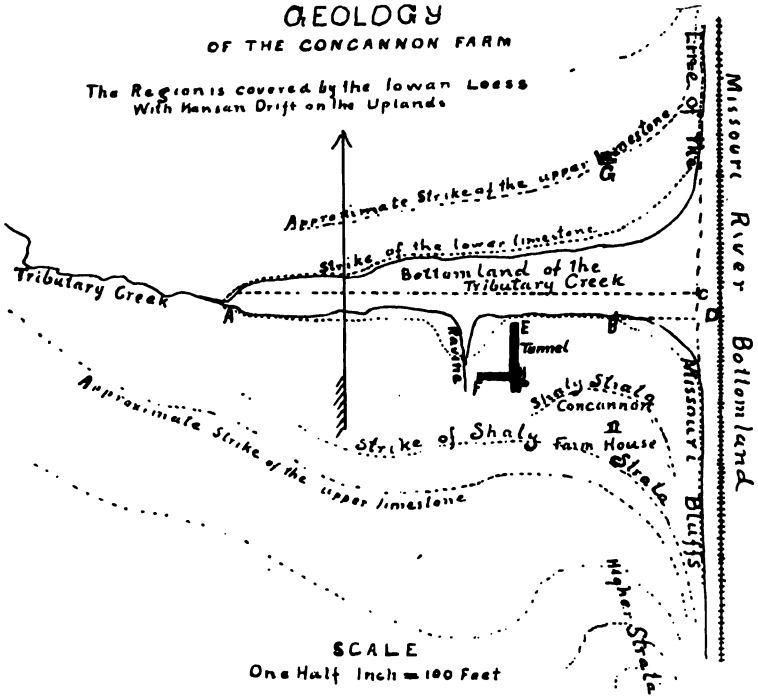


Fig. 2. Map of a part of the Concannon Farm.

4. At this point it will be necessary to refer to the following diagram; in which A represents the point at which the lowest rock appears in the creek bottom. At this place there is a little rapid spot and a good watering-place for horses. The rock exposed is the same stratum as forms the floor of the tunnel. B represents the most eastern point at which rock *in situ* is seen in the south bank of the tributary creek. C and D are points situated in the creek valley directly eastward from A and B, but on a line coincident with the average line of the Missouri bluffs as they strike past the mouth of the tributary. E is the entrance to the Concannon tunnel. F is the entrance to the open tunnel. G is the quarry on the north side of the creek. H is the place of the skeleton. The plan is approximately drawn to scale.

As to the temporary nature of the creek, it is found, by following it up, that the valley extends about a mile westward, formed by three tributaries that drain about one square mile, and that it is wide and deep, but rarely showing rock, comparable with its appearance at its mouth. Mr. Michael Concannon has stated in writing: "In my memory, some thirty or more years, the creek has never been dry above A, while below that point it is dry every summer. Between the cellar and A there is no rock vissible, but the ledge that is in the creek bottom at A is the same that is in the floor of the cellar. The distance from A to C is five hundred and ten feet. The distance from B to D. is ninety-six feet. We have never discovered any rock in the north bank of the creek. The quarries on the north side are about seventy-five or eighty feet higher than the cave level, [and] near the top of the river bluff. Immediately east of the [entrance of the] tunnel the creek has excavated its bed twenty feet or more, while a little further east we had a well twenty-four feet deep and did not strike bedrock." Piles were driven thirty feet in the alluvium in the construction of the railroad bridge over the creek at its mouth.

Here is a creek valley, therefore, which has been excavated in the rocky structure of the Missouri river bluffs at least seventy-five or eighty feet, from the quarries on the north bluffs down to the level of the floor of the tunnel at E. and thence (say) twelve feet to the level of the creek's flood-plain, and

deeper still at least twenty-four feet below the surface of the creek's flood-plain — in all, a known excavation in the Carboniferous limestones and shales a perpendicular gorge one hundred and eleven feet deep, with a probability of fifty feet still deeper at the creek's mouth, and at least fifty feet of strata lying above the quarries on the north side. In other words, this little "periodic run-off" develops, on being examined, into a constant stream occupying an ancient gorge that dates probably from pre-glacial time.

Whether the present channel is "aggrading" at the present time, while the bottom land of the Missouri adjacent is in a degradational stage (No. 5) is beyond the scope of the writer's immediate apprehension. He can only state that it would be a condition of contrariety at the point of junction of two streams which appears singular, if not inconceivable, and especially in the light of the perfect adjustment which is affirmed (in No. 2) as a concomitant condition.

5. Whether the bottom land of the Missouri at the Concannon farm is at present being lowered as the resultant effect of scour-and-fill, or is being raised, the writer has no positive data by which to form any opinion. That the Missouri river once flowed past the site of the Concannon farm with its surface from fifty to seventy-five feet lower than at present, as all along its course in its pre-glacial gorge, there is abundant evidence to show. That this deep rock-cut gorge was affected by the recurring glacial epochs cannot be questioned, and that it was filled to its brim, and sometimes beyond, by the Iowan epoch is demonstrable. That this filling was by water at certain latitudes, by silty water at others and by silt, called valley loess, at others is perhaps equally demonstrable. That this stratified valley loess, at still higher latitudes, grades insensibly into the upland loess, losing gradually its preference for the immediate valley, and *pari passu* its water-laid structure and assortment and that this loess has been re-excavated by the stream, is in the opinion of the writer as evident as any geologic principle of Pleistocene time. That this re-excavation was interrupted by the waters resulting from the Wisconsin epoch of glaciation, and the action was reversed, so that a refilling began, is proved by the Wisconsin terraces that now rise higher than the river level. That the Wisconsin terraces toward the north

are composed of northern gravel derived from the Wisconsin glaciers, but toward the south are formed of whatever materials the surrounding country could supply, and that they descend southward faster than the present descent of the rivers that formed them, so as to disappear by submergence under the wider bottom lands, are propositions that are admitted by most Pleistocene geologists. That the Missouri has, in some places, excavated a channel into the deposits of the Wisconsin epoch, forming Wisconsin terraces, and at others has filled its pre-Wisconsin channel by additions to its flood plain, is quite certain. That this excavation should be toward the north and this re-filling toward the south is also quite certain. Whether the Concannon farm is above or below the point of transition from the latest re-excavation to the latest refilling, it is impossible, from any data at hand, for the writer to state. It seems to be below, and therefore that the present resultant of scour-and-fill at that point is a small addition to the hight of the floodplain. But owing to the importance attached to this by the hypothesis urged by professor Chamberlin the reader will find a more ample discussion of it under No. 22.

6. The shallowness of the aggradation deposit at the mouth of the tributary is very important to the hypothesis of professor Chamberlin. If it is deep enough to show excavation in the rock in the manner of a gorge it implies that the creek occupies an inherited channel, and that the Missouri also must have been running at a lower level when that gorge was excavated, and no such event has taken place since the Wisconsin ice-epoch. The statement of Mr. Michael Concannon that a well sunk twenty-four feet in the creek bottoms a little east of the mouth of the tunnel did not encounter bed rock and that piling thirty feet long was driven for the support of the bridge, is all the information the writer has bearing on this point directly. But inferentially he has much evidence that the creek had a pre-glacial adjustment with the pre-glacial Missouri at a considerable depth below its present adjustment plain. In the first place, the whole surrounding topographic contour shows that this creek's valley is exactly like almost innumerable tributary valleys that enter the Missouri and the Mississippi rivers south of the Wisconsin morainal belt. There is no topographic, nor other, reason to exempt it from the

uniform character and history of the region, viz: *the creek occupies an inherited pre-glacial valley,* and its buried adjustment with the trunk stream must be many feet below the present floodplain, the intervening distance being the measure of the thickness of the total aggradation deposit. In the second place the sinking of the water of the creek every summer, as stated by Mr. Concannon, below A in figure 2, and its never disappearing above A, indicates that it does not flow on the rock from A to C, but on the contrary that it enters at A upon a mass of loose aggradation deposit into which it sinks at once. Again, the fact that the massive, level limestone layer that constitutes the floor of the tunnel, say twelve feet above the top of the creek's aggradation deposit, is cut away from C to A, a distance of 510 feet up the creek's valley, shows that there was a water-fall during this period of cutting; for this layer of limestone is underlain, at the entrance to the tunnel, by more shaly and erosible beds. From B to A this water-fall (or rapid) must have receded, and at an earlier date also from C to B. Such durable layer of rock, lying between shales above and below, not only must have caused a sudden increase in the descending gradient of the stream, but must have been the primary cause of the excavation of a gorge in the softer shales lying below. Hence it is easy to infer, given the creek, and the limestone layer, that there is more or less of a gorge all the way from C to A, now filled by the aggradation deposit in question. It is not necessary to dwell on this point. It is impossible to discuss the age of this little creek in an impartial and thorough manner and exclude such early history.

7. The statement made in No. 7 must be explained by reference to some preconceived idea on the part of the author supplemented by a hasty and casual examination on the spot; for the facts, as ascertained by the writer, are quite at variance from it. The thickness of materials to which professor Chamberlin here refers rarely, if ever, reaches four feet. But, whatever it may be as to actual thickness, it will be assumed here that he refers to the water-laid silt (3 in. thick) and the materials that underlie it. In this the writer could find no "earthy debris," properly so called, no "glacial drift," no "loess" (like that which overlies the silt layer, or that which mantles the

general region), nor any "river valley wash," nor any "heterogenous mixture." It is a homogeneous, uniform, exceedingly fine,, non-effervescing clay, containing only debris from the adjacent Carboniferous strata, its nature being more that of a residuary clay than anything else that the writer ever saw. In its lower portion, and at higher levels where the skeleton was found, are masses of Carboniferous limestone, but the leaching and rotting have been so thorough that the calcium carbonate is not appreciably distributed in the matrix in which they lie; but each limestone mass is surrounded with a coating, from half an inch to two inches thick, of its own undisturbed residuum. Hence they are slippery, when wet, and unhandy to move or to break with a hammer. These large limestone masses are more and more frequent toward the face of the tunnel, being almost wanting below the silt layer at the entrance. The writer made a microscopical examination of the substance below the silt layer. After repeated decantation from a handful washed repeatedly in a jar, from which therefore the finest grains were supposed to have been removed, he was surprised to find that the finer of the remaining grains and all the coarse ones, were perfectly homogeneous and uniform grains of itself. These homogeneous grains showed, still, that they were compound, and consisted of aggregations of grains of an excessively fine substance. A number of mountings were made, in an effort to ascertain the nature of the ultimate particles. In each instance the mounted grains showed still their composite structure: until, at last, the very dust that adhered to the white paper from which the visible grains had been shaken off, was put on the slide and covered in Canada balsam. Scattered amongst some still compound grains were seen, in the highest powers, the isolated, ultimate grains of the substance. They appeared to be entirely of ragged fragments of kaolin, never showing any roundness that could be attributed to friction under transportation. When aggregated these fine particles interfere with the transmission of light, and, owing probably to the presence of a small amount of iron oxide, the small clusters appear nearly opaque except at the extreme ends of small projections. This oxide also gives the brown stain which characterizes the clay in bulk.

A similar examination was made of the stratified silt layer, with similar results. If casually examined this silt would be pronounced highly calcareous—and so it is *en gros*. But it is apparent, on closer inspection, that this carbonate of lime is largely confined to loess-kindchen formed in it, or to encrustations and fillings that occupy the numerous fissures by which it is cut. These fissures are very numerous and very tortuous. They cause the dry silt, when excavated, to crumble into a thousand polygonal masses that roll out almost spontaneously. They are abundantly coated with a white deposit of carbonate of lime. When thoroughly washed and freed from this secondary deposition of carbonate of lime, these masses do not effervesce freely on the application of hydrochloric acid, but if they be immersed in such acid there appears a languid attack of the acid in the escape of a few fine bubbles of gas, showing that the secondary deposition has also penetrated the interior of the silt. There is another slight difference observable in the microscopical mounting, viz: the silt contains also rounded or angular grains of quartz of much greater size than any seen in the clay underlying. But with those two exceptions this silt is, microscopically and chemically, identical with the clay that underlies it. The character of those two layers, taken together, seems to indicate a common origin for the bulk of the material of which they are composed; and also that the silt is referable to a washing action from the underlying clay; such action having also introduced some coarser quartz particles not derivable from the immediately underlying clay though probably from the surface adjacent. The absence of drift materials from the clay and its scantiness in the silt indicate that they originated in pre-Iowan time. The addition of lime in excess to the silt is due to the downward leaching from the overlying loess. The sample of the silt examined by the writer was obtained near the entrance to the tunnel. He is not able to affirm that the little fissures are as frequent, and as calcareous, at the other end of the tunnel, but he noticed no difference. His sample from the underlying clay was obtained near the place of the skeleton.

The writer is under obligations to Dr. C. P. Berkey for the determination of the percentages of carbonate of lime in Nos. 1, 3 and 4. He has made the following statement:

Prof. N. H. Winchell,

Dear Sir:—Analysis of the samples of material for lime content gives the following results:

No. 1. (Natural) Lime ($CaCO_3$) = 1.109%
No. 1. (Washed) Lime ($CaCO_3$) = 0.975%
No. 3. (Natural) Lime ($CaCO_3$) = 3.550%
No. 4. (Natural) Lime ($CaCO_3$) = 5.207%
No. 4. (Washed) Lime ($CaCO_3$) = 5.23 %

Mineralogical Laboratory.

Charles P. Berkey.

These analyses indicate a considerable increase of carbonate of lime in No. 4 over No. 3 (from the roof of the tunnel), due to downward leaching, whether washed or unwashed. It is quite probable that the feeble apparent attack of acid on No. 4 when washed is in a large measure due to its fineness of grain.

Microscopical examination of the loess (No. 3.) overlying the silt layer disclosed grains of several minerals found in the crystalline rocks, such as feldspar, hornblende, magnetite and, most frequent of all, quartz. These are from 10 to 100 times the size of the ultimate grains found in Nos. 1 and 4.

8. The silt layer is very evident on the west side of the tunnel. Its fissured character has been described. After the tunnel had been extended further by Mr. Fowke, and an offset had been excavated toward the east, the characters at the inner end of the tunnel, in the east side, as described by professor Chamberlin, seem to show that the stratified silt layer actually does appear on the east side. These characters are mentioned and quoted in his words under No. 10.*

9. There is no call for adverse comment on Nos. 9 and 10, for the writer saw the same features. Those mentioned under No. 9 are particularly interesting as they show the wide extent of the structure lines apparently controlled by stratification in the main loess deposit. They are probably more evident in situations near the Missouri river than in the sheltered angles, and therefore they apparently increase toward the east. Still, in the eastward offset tunnel cut by Mr. Fowke the material is wholly geest, and shows no horizontal structure lines like those seen in the loess of the main tunnel. The

* Later examination shows that the eastward offset referred to is excavated entirely in the fine geest, with few residual limestone fragments. The vertical jointage described by Prof. Chamberlin pervades the whole mass of geest, both here and on the face of the tunnel.

writer's sample No. 1 was obtained in the floor of the offset tunnel, a little eastward from the place of the skeleton.

11. The peculiar character of the water-laid stratum of silt, and its calcareous ingredient have been discussed under No. 7. Its marked resemblance to the layer on which it lies, and their remarkable differences, in structure and composition, from the loess that overlies the silt stratum, set them off from the rest of the materials pierced by the tunnel, and require for them an earlier date and a different mode of accumulation. (See Appendix.)

12. How can a limestone become "softened," in the ordinary use of that word, unless it become rotted? Limestone does not soften either by atmospheric exposure or by moisture, unless it is chemically so changed that it has lost its carbonic acid and has acquired water. Such an alteration can hardly be expected in materials deposited by the waters of the Wisconsin glaciation, much less by operations of flood-drainage within more modern time. These "softened" limestone fragments could not have been introduced into this deposit in their present condition, but they must have rotted *in situ.*

13. The description of the main material cut by the side tunnel of Mr. Fowke is nearly as the writer would make it—he only would add that the arrangement of the coarse material, whether of limestone or of "other debris" is sometimes in indistinct horizontal bands or belts, and that the other debris is in part of drift pebbles which are also in the main rotted *in situ,* indicating a longer age than since Wisconsin time. Rounded quartz pebbles about half an inch in diameter were taken by the writer from some of these belts of coarser debris, all the other pebbles having become so "softened" that their positions were shown by white spots, when of limestone, or loose rusty spots when of "other debris." The "gravelly aspect," moreover, so far as observed by the writer, was confined to such horizontal belts, although the rotted stones were seen scattered more or less throughout the mass. The loess-kindchen are notably most abundant in the horizontal gravelly belts.

Whether this should be called "a typical loess deposit" depends on what and where the type deposit is found and when

found whether it were acceptable to all. It is unquestionable that the usual descriptions of loess, published many years ago, and especially those that were applied to the loess, say at Vicksburg, Mississippi, or to most of the southern points along the Mississippi river, would not fit this deposit. There are, however, on record many descriptions, applied to points further north, say in Iowa, in Illinois, in Missouri, South Dakota and in Minnesota, which will fit this loess deposit. It is chiefly due to the research of Mr. W. J. McGee that the extreme southern features have been found to fade out toward the north, and to be replaced by what might be styled northern features, and at last by extreme northern features, the loess becoming more and more like the northern drift, and at last even passing horizontally, as well as vertically, into the northern (Iowan) till. Some southern geologists long ago concluded from studies in southern states that the loess of those states is a deposit contemporary with the northern drift, but they did not elucidate the manner, nor the place, of transition from loess to drift in passing toward the north. In like manner some northern geologists found a contemporary and continuous sheet extending from one deposit to the other and, while announcing distinctly that fact, failed to define fully the manner and cause of such transition. It required examination in a middle latitude (Iowa) where, as already stated, Mr. McGee worked on the Pleistocene history of northeastern Iowa with great thoroughness and high appreciation of the problem, to bring this curious fact, so long wholly unknown, to a clear and indisputable explanation and publication. With the light thrown on the nature and origin of the materials of the loess by the descriptions of Mr. McGee, it is obvious that the typical idea of loess is subject to great extension and alteration, and hence that the deposit on the Cancannon farm, overlying the human skeleton cannot at present be excluded from the category of typical loess. The writer has fully discussed this at another place,* and will not dwell on it again. He will only add that, in his opinion, there is no feature of the deposit lying over the Lansing skeleton (above the water-laid silt layer) which is incompatible with the designation *locss* for the latitude and the Pleistocene geology of the region.

*Geological Society of America. Presidential address, Washington, 1902.

In order, however, that this transition from the features of the loess to those of the Iowan till may be made to appear widespread, as it is, the writer will add (besides the remarks on the discussion of the South Dakota drift by professor Todd, given under No. 14) the following references:

Professor T. C. Chamberlin, indorsed the idea of the transition, horizontal and vertical, of the Iowan till to loess in his introduction to the last edition of Geikie's "Great Ice Age." *Jour. Geol., vol. 3, p. 273, 1895.*

Professor J. E. Todd, in his description of "the moraines of southeastern South Dakota" (Bull. No. 158, p. 93) mentions, among the relations of the drift to the loess, a gradual passage from one to the other, essentially similar to that de-

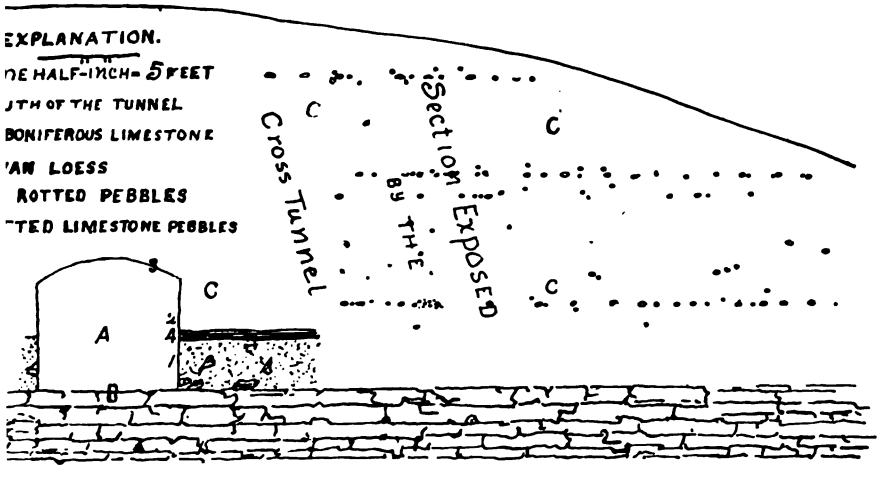


Fig. 3. Section of the tunnel parallel with the cross-cut of Mr. Fowke.

scribed by N. H. Winchell in 1877, in southwestern Minnesota. There are numerous statements of facts, and some illustrations by figures, in the same work, that lead to the same idea. Professor Todd also quotes Chamberlin to the same effect. (Missouri Geol. Survey, vol. 10, p. 210, 1896.)

Professor Calvin, in his report on Page county, (Geology of Iowa, vol. XI, p. 446, 1900) clearly describes the pebbly drift-loess of McGee, under the heading "flooded valley deposits." "In nearly all the valleys of Page county there is a formation which in some of its phases resembles loess; but in other of its aspects it is clearly an aqueous deposit. It has

evidently been laid down since the valleys reached approximately their present depth. * * * It is yellowish in color, tough, jointed, and obscurely stratified. Unlike loess it contains occasional pebbles and pockets of sand. A small greenstone, two inches long and showing glacial planing on two sides, was taken from this silt in the bank of North Branch. * * * Above the section described at Braddyville, west of the railway track, there is a body of the clay twenty feet thick and forming a distinct terrace fifty yards or more in width at the top. The hard enamelled scales of the garpike, Lepidosteus, were found in this bed at Braddyville, the scales retaining their proper relations to each other as if the fish had been buried at the time the silt was forming. * * * The same yellow silt is found beneath sandy alluvium in the valley of Buchanan creek, east of Braddyville. It is well shown in the bank of the Nishnabotna river west of Essex, where it is overlain by six feet of a fine, loess-like silt and two or three feet of black loam. At the Rankin Brothers' brick yard at Shenandoah the section of the clay pit shows

3. Loess-like clay ..... 8 ft.
2. Bluish, stratified clay, clearly an aqueous deposit, but flexed more or less as if laid down on an uneven surface ..... 8 ft.
1. Porous, dark, granular clay..... 7 ft.

* * * * * * * *

"Nos. 1 and 3 resemble loess, but No. 2 records a distinct episode between the more recent and the more ancient period of loess formation, during which the valley was temporarily flooded."

"The distribution of this deposit is practically universal in all the valleys below a certain level." Professor Calvin suggests two hypotheses for the date and origin of this material—one, that it was deposited during the Kansan epoch by the melting of the Kansan ice, the other that it resulted in the same manner round the margin of the Iowan drift, the latter being the explanation now generally accepted. Page county is one on the southern boundary of Iowa not far from the Missouri river, and almost due north from Lansing.

Professor J. A. Udden, in describing Pottawattamie county (Geol. Iowa, vol. XI, p. 260) situated a little northwest from Page county, but bordering on the Missouri river, says that

in the loess, meaning here the upland loess, the lower half of a deposit ninety feet thick, near Loveland, on the Boyer river is "pebbly."

Mr. H. F. Bain gives (Geol. Iowa, vol. 5, p. 276, 1896) important instances of the cotemporaneous deposition of northern till in the loess, with illustrations. This is in Woodbury county, bordering on the Missouri, north of Pottawattamie county.

He remarks that, for the exposure near Riverside station, the explanation has been offered of a slipping of till and loess from higher levels down into a lower terrace of loess. At another point, however, he claims that, whatever the case at Riverside station, that explanation cannot apply. It is at a sand pit northeast of the Brugier bridge, and he gives a full page photographic illustration. This exposure is "about 150 feet above the river, and the till is above any similar deposit known to occur in this vicinity. The exposure shows a bed of typical till consisting of a matrix of dark brown clay, in which are numerous boulders of Sioux quartzyte (one of these is pointed out by the hammer) and other northern rocks, with loess of the usual character, both above and below. * * * The presence of the till in the loess indicates the cotemporaneous origin of the two deposits, and it seems clear that in this case the explanation offered for the Riverside exposure cannot suffice, even if in that it be deemed sufficient."

Such descriptions could be multiplied.

14. These features are usual in the drift-loess further north. They have been mentioned by Todd in his account of the moraines of southeastern South Dakota and their attendant deposits,* although in his descriptions professor Todd strives to sustain a distinction between the loess and all forms of drift. It is plain, however, that such distinction was difficult (see pages 80, 82, 84, 88 and 89, of Bulletin No. 158). The terms till, or pebbly till, pebbly clay, or simply drift, are sometimes applied by him under the force of a theoretical distinction where the term loess would also apply; and in some cases, without a theoretical distinction, would be preferable, especially in those exposures of pebbly "till" which he ascribes to subaqueous deposition (pp. 65 and 66). According to Todd char-

* *Bulletin No. 158, U. S. G. S.*, 1899.

coal is a common feature of the loess near its base. Todd also frequently mentions, and sometimes illustrates in his figures, a stratum or several strata, of stratified silt near the bottom of the loess, such as, according to professor Salisbury, are exceedingly rare at the bottom of the loess, and which are comparable to the silt layer at the base of the loess at the Concannon farm.

15. The Unio which was taken from the roof of the tunnel at the Concannon farm by professor Williston and Mr. Long was shown to the members of the party, and to the writer, at the time of its extraction. It has been stated that its valves were still united, but of that the writer knows nothing further than the statement of professor Chamberlin, p. 769. In case this Unio were a true fossil, it would be, of itself, sufficient proof of the subaqueous deposition of the materials in which it lay. Land shells may form fossils in aqueous deposits, but never water shells in land deposits. It is, a priori, however, the strongest evidence of sub-aqueous origin of the loess in which it was found, and the agreement which it has with the obvious other features of the deposit serves to accumulate such a weight of testimony in the same direction that it requires the greatest hardihood to attempt to explain it on the hypothesis of land origin of that deposit.

16. The statement here made shows the needlessness of the "academic statement" concerning scour-and-fill, for this complete statement of theory makes no appeal to scour-and-fill. Indeed, it is evident, from the position of the tunnel as shown in fig. 1 (Prof. Chamberlin's fig. 13), that the Missouri river is shut off from access to the place of the skeleton by the Carboniferous bluff. It might reach it by back-set of water, if it were ever high enough, forming a bayou up the creek's valley, but the operation of scour-and-fiill is confined to the channel of the river.

As to the extent of the deposit, containing the skeleton—that is not determined by any facts yet brought to light. It *appears* to be the same deposit that covers the region. It ascends the higher slopes, i.e., unless some distinction can be made to appear by future exploration, fills the ravines and gorges adjacent, and is not terraced or otherwise topographically or areally set off as separate from the loess of the region.

It would be very useful in this investigation, to make sundry pits or small trenches in the loess round about in order to ascertain the differences, if any there be, between this and the great loess mantle that covers the rocks of the region at this altitude.

17. There is no reason to doubt that the evidently water-laid layer of silt was put there by "some unusual flood." It appears that the Missouri river flowed at that level at that time. Owing to the integrity of the underlying geest it is evident that the river was not at that time in a stage of active erosion. The relations of the silt to the geest imply that the submergence by the river was not changed to emergence before the deposition of the overlying loess. The relations of the silt to the overlying loess imply that, the submergence continued, there was a copious rather sudden deposition of more distantly transported material by the same agent as deposited the silt. The "unusual flood" may have been the rising of the Missouri introductory to the Iowan loessian floods. However broken the record in other places, or however limited the present sheet of silt, where it is intact its record is good and the missing links of the history at other points should be supplied by restoration from the perfect record wherever preserved.

18. The existence of this post-Kansan (or perhaps pre-Glacial) valley should, according to professor Chamberlin, lead any experienced, unbiased, Pleistocene geologist, to expect either a hanging or a buried adjustment of earlier date upon the main stream. As there is no hanging adjustment there must be a buried one as already shown in No. 6, and hence the present adjustment is "accidental"— one of those inherited accidents that post-Wisconsin Pleistocene geology is so filled up with. According to the depth of water stated by Mr. Concannon, quoted by professor Chamberlin, that early adjustment must be at least ninety feet below the present level of the Missouri.

It is evident here, and especially by reference to page 752 of the *Journal of Geology,* that the word adjustment is applied to the hanging or the buried type when brought by professor Chamberlin into contrast with the present adjustment, and hence that, if the present has obliterated or abandoned an old place of adjustment, without having inherited it,

the creek (which must have been the agent in producing the change) must either have cut down a hanging adjustment or must have cut, at its mouth, a new rock-bound channel down to the level of the present adjustment. This achievement is discussed in No. 20.

19. It is quite difficult to see how the age of the original valley, and of the upland mantles can be excluded from anv geological investigation of this problem, unless, by an arbitrary and quite precipitate assumption, the deposit in question is entirely a modern accident, and all the surroundings must be made to agree with that accident as a starting-point. But, allowing the exclusion of these questions except on the specified condition, it appears to the writer that even on that condition the age of the original valley and of the upland mantles is very essential to the investigation, for that specified condition as shown in No. 6 is plainly supplied.

20. In other words: it is possible that a tributary creek, rising say 300 feet above the Missouri, running in a valley that is cut in the Carboniferous rocks at least 200 feet, down to the level of the Missouri at Concannon's and at least 24 feet below its present floodplain, may be in its original gorge except near or at its mouth, where it may be in a new channel fashioned by recent agencies. If that is possible, it is possible for a creek to get out of its rock-bound gorge at some point above its mouth, and at its mouth to cut a new gorge at least 100 feet in depth by the operation of "recent agencies"—i.e. since Wisconsin glaciation—a task which, so far as known to the writer, no creek has ever accomplished, especially no "periodic run off." The valley at its mouth is rock-bound on both sides. If professor Chamberlin's supposition does not refer to this rock-cut channel, but to the present shifting position of the little dry channel that meanders through the creek's floodplain at its mouth, it is necessary to admit that recent agencies have determined its position. But that contravenes his hypothesis, since the creek's antecedent valley, as already shown once occupied by the creek, continues to the Missouri at the same place underneath the present creek, and the present floodplain and its little dry channel are but accidents dependent on the vicissitudes of every season. If his hypothesis refers to any other stage in the waters of the creek, between its

present and its pre-Wisconsin condition, or to any supposed earlier floodplain, between its present and its pre-Wisconsin floodplain, the same is true—i.e., all those stages and floodplains were events witnessed by the antecedent valley in which the creek now lies from its mouth to an indefinite distance toward its source.

21. This remarkable statement, if the writer understands it, is so far at variance with what is known of existing channels, outside the area of Wisconsin glaciation, and especially within the loess-covered areas, that, in the opinion of the writer, the truth would be nearer the exact opposite. There is certainly not a stream entering the Mississippi within Minnesota, from St. Paul to the Iowa state line, that does not flow in a valley that far ante-dates the Wisconsin glaciation, and probably the Iowan, especially at its entrance upon the Mississippi's great gorge.

If, however, reference is not intended to the general stream valley (which, still seems to be the fact by reason of allusion to the "creation of the Missouri river by the union of many antecedent rivers") but to the present channels of the streams concerned as they make their shifting ways through the floodplains, it must be granted that such channels have no stability, and are likely not to be the same for any length of time. They are subject to the floods and droughts of the seasons; and especially is that true if comparison be made between the present floodplain channels and those that preceded the Wisconsin glaciation. But such alternative seems not to have any bearing on the main question, and further, it contravenes the principal hypothesis, which marks back to the time of the "creation of the Missouri." (Compare No. 18.)

22. The glacio-fluvial deposits of the Wisconsin epoch may be wanting at the Concannon farm. We have mentioned some considerations (Nos. 5 & 13) leading to the belief that they never existed there in the form of fluvial terraces. If as supposed by professor Chamberlin they have been removed, their existence at some points, in some of the bayous or in some of the mouths of the tributaries, should still be recognized. The Wisconsin terraces, if they ever existed along a river like the Missouri, are never obliterated, so far as observed by the writer, so as to leave no trace through long dis-

tances. Still, granting that they have been there and have been removed, their removal must have been effected by a river whose water surface was lower than the Wisconsin terrace. The hight of a Wisconsin terrace according to professor F. A. Wilder's* careful discriminations, in Lyon county, on the Big Sioux river, which is about 300 miles farther up the Missouri valley, is ten feet above the adjacent floodplain, continuing to the mouth of the Big Sioux. According to Mr. Upham this terrace is still visible between the mouth of the Big Sioux and Council Bluffs, the most southern point still being 140 miles from Concannon's farm. This terrace, so far as known has not been identified at lower points, and it doubtless disappears in the present floodplain of the Missouri river at many miles north of the Concannon farm.

Corroborative of this conclusion is the interesting presentation of the descent of the Wisconsin terraces by professor J. E. Todd. According to his tabulation the descent of the lower "bouldery terraces" (the Wisconsin terrace?) along the Missouri is as follows (Bulletin No. 158, U. S. Geol. Sur., p. 137), measured by aneroid:

Opposite Niobrara its hight is.....	200	feet.
Niobrara, S. Dak.....	210	"
Yankton, S. Dak.....	140	"
Vermilion, S. Dak.....	100	"
Blair, Nebraska	110	"
Calhoun, Nebraska	100	"
Bellevue, Neb. (8 ms. S. E. of Omaha)..	70	"

Measured as the crow flies the distance from Niobrara to Bellevue is about 150 miles and the descent is about .93 foot per mile faster than the descent of the river. The distance from Bellevue to Lansing, measured in the same way, is about 150 miles. If the same relative rate of descent were continued below Bellevue the descent of the Wisconsin terrace to Lansing would carry it 69.5 feet, below the surface of the river, at Lansing. Owing, however, to the roughness of this calculation, and to the uncertainty of the data on which it is based (aneroid levels), its chief value consists in showing the southward lowering of the Wisconsin terraces, and the certainty of their being lost in the present floodplain at an indefinite

* *Iowa Geological Survey*, vol. x, 1900.

distance from the latitude of the Wisconsin morainic belt. It is quite possible also that the "lower bouldery terraces" of professor Todd, rather than being of the age of the Wisconsin ice-epoch are the parallel of the higher gravels in the Big Sioux valley which professor Wilder has assigned to the Buchanan gravels, and that the Wisconsin terrace is that of professor Wilder, already mentioned, which lies much lower and must soon disappear in the bottom land of the Missouri. According to professor Chamberlin, however, (*Jour. Geol.* p. 771) the bouldery terraces of Todd "are directly connected with the first and second stages of Wisconsin glaciation."

This goes to show that the Missouri river at Lansing has not had a water surface, since Wisconsin time, lower than the Wisconsin stage at the same place, at least that it has not removed any Wisconsin terrace at that place, and inferentially that no Wisconsin terrace ever existed there.*

The view here presented as to the sinking of the Wisconsin terrace below the bottomland before reaching the latitude of the Concannon farm was presented by Mr. Warren Upham in the January, 1903, number of the GEOLOGIST. It is his opinion that the Wisconsin terrace sinks into the floodplain of the Missouri not far below the mouth of the Platte river.

If no Wisconsin terrace ever existed at the place of burial of the human relics, the Iowan loess has there been exposed to surface wash and removal, and no later Pleistocene record has been superimposed so as to erase or obscure the Iowan record. Further, the little tributary creek, dependent at its mouth on the post-Wisconsin elevation of the floodplain of the Missouri, has not only not had any Wisconsin stage of floodplain higher than its present floodplain, but since Wisconsin time has had no higher floodplain than its present. What and where the Iowan fluvio-glacial deposits may be is quite another question, but, as already stated, the Iowan stage of the Missouri was so high that it not only filled its original gorge but in some places flooded much of the adjacent region. On its retirement its deposits, which we know as loess, stratified and semi-stratified, originating in the Iowan till, silted back by the regional subsidence, were cut into by the streams

* This regimen of rivers with respect to the Wisconsin terraces has recently been discussed by Prof. Chamberlin in the *Journal of Geology*, vol. xi, p. 75, Jan.-Feb., 1903.

which again in the main assumed their pre-Iowan valleys. It appears therefore that this process of re-excavation of the upland valleys has continued to the present without the superposition of any later record, accompanied in the river valleys, as already stated in No. 5, in some latitudes by re-excavation of the Wisconsin till and terraces, and in more southern latitudes by a gradual increment in the hight of the floodplain of the Missouri. What more natural therefore, or more inevitable, than that along the rivers the Iowan loess should be found lodged on all pre-Iowan rock-spurs and bluffs, and that all the inequalities of the pre-Iowan surfaces should be expressed with greater or less clearness in the contours of the present loessian surfaces. In case, under pre-Iowan decay, a firm rock layer, overlain by an easily weathered mass of shale, had formed a projecting shelf on which had gathered a mass of geest and semi-geest in pre-Iowan time, as appears to have been the fact at the Concannon tunnel, the same sheltering surroundings would also preserve the Iowan loess on that rock-shelf and might produce, as appears to be the fact at the Concannon farm, an imperfect, blind terrace-like platform. Such platform, however, would in no sense be an Iowan fluvio-glacial terrace, although its materials, in their present posé, might date from Iowan time, and be a part of the Iowan fluvio-glacial deposits.

23. Again, this final summary statement as to the origin of "the little relic-bearing deposit" testifies to the needlessness of the "academic statement" as to scour-and-fill, since it makes no appeal to scour-and-fill.

The human remains were in, or below, a loess which rises and extends over the surrounding bluffs, formed by the methods of distribution known as Iowan. As shown in No. 22, the Missouri river never flowed, since Wisconsin glaciation, at low stage, any higher than it does at present, and therefore never as high as the floor of the tunnel, and never formed, since Wisconsin time, a floodplain as high as the top of the relic-bearing deposit. The circumstances of the fluctuation of the Missouri from one side to the other of its channel, of scour-and-fill, of wash from the hill-sides, of changes in the floodplain of the tributary valley, of the demolition of the Carboniferous bluffs and of the Kansan sheet of the drift, are still going on, have

continued since the spreading of the Iowan glaciation; but since Wisconsin glaciation the normal action of the river and of the creek has not risen above its present plane of effectiveness and never higher, even in greatest flood-stage, than the floor of the tunnel. The date of burial, therefore, is to be determined approximately by the length of time elapsed since the spreading of the Iowan loess, which, compared with the age of the Kansan drift seen scantily spread on the highlands was an event much nearer the end than the commencement of the Glacial period.

What events may have taken place after the spreading of the Iowan loess, during the period of surface degradation anterior to Wisconsin glaciation, it is not necessary, at the present time, to enquire, although they may have been competent, perhaps under some such process as urged by professor Chamberlin, in covering these remains where they were found. That would make their burial pre-Wisconsin and post-Iowan.

Concise statement of the two views.

Professor Chamberlin's interpretation of the facts requires:

1. A floodplain built by the united action of the creek, the river, and the wash from the adjoining bluffs, in post-Wisconsin time, thirty-two feet more or less above the present floodplain.

2. In order to that, the interpretation assumes that the river flowed, in post-Wisconsin time, at low water stage at 18 feet above the present floodplain, and eroded the shale overlying the rock constituting the floor of the tunnel.

3. It requires a heterogeneous mixture of floodplain composition, made by the agents specified, rising from the floor of the tunnel to the top of "the little relic-bearing deposit," such deposit being different in date, origin and composition from the Iowan loess covering the uplands adjacent, and about twenty feet thick.

Those three points comprise the essentials in his theory, all other attendants being of the class of academic statements or intended to establish these three.

The writer's explanation requires:

1. The identity of the bulk of "the little relic-bearing deposit" with the Iowan loess of the region.

2. The recognition of the geest which lies on the rock and rises three or four feet above it, and the derivation of the water-laid silt layer by wash from the geest.

3. The impossibility of the Missouri river and the tributary creek being in erosive contact on the floor of the tunnel at low water, since Wisconsin glaciation, or flowing at a higher level than at present, and hence the impossibility of there having been at the mouth of the creek any Wisconsin terrace, or post-Wisconsin floodplain forty-two feet more or less above the present floodplain.

All the rest of the writer's discussion foregoing is simply attendant on the establishment of these points, necessitated by the glittering phantasma of Pleistocene geology involved in the establishment of the other hypothesis.

Some argument has been drawn in favor of the recentness of the burial from the resemblance of the skull to those of the present Indian, and from the freedom of the skull and bones from encrustation.

In reply it may be remarked that not only is there a tendency amongst glacialists to shorten the Iowan ice-epoch, but to unite it rather closely in time with the Wisconsin. The date of the Wisconsin being generally approved, as about 8000 years ago, and the Iowan probably not more than 8000 years older, it appears that man may have acquired the physical characteristics of the Indian at that comparatively recent date.

The burial of the skeleton, as represented by the discoverers, in the non-calcareous geest, overlain by an impervious silt layer that intercepted the downward passage of calcareous water from the loess above, is perhaps sufficient to account for the non-calcareous condition of the bones.

Since the publication of professor Chamberlin's paper, professor W. H. Holmes has discussed the same subject in the *American Anthropologist* (vol. 4, pp. 743-752, Oct.—Dec., 1902), and has followed the argument and reached the conclusions announced by professor Chamberlin. He could hardly do otherwise. It is a geological rather than an anthropological investigation, as the essential data are involved in geologic science.

APPENDIX A.

The following letters throw additional light on the question of the age and nature of the deposit in question. It is evident that the terraces of the Missouri should have special examination.

Note from Professor Williston.

Chicago, Feb. 17, 1903.

Dear Professor Winchell: Pardon me for not replying immediately to your letter.

The clam was dug from the extreme angle of the tunnel, near the door, by Mr. Long and myself, at about seven feet above the floor, that is where the roof joins the wall. We at first thought it was bone, and I did not recognize that it was a cast until after I examined it at Lawrence. The hinge line and markings of both lateral valves were (and are, if they have not since been injured) quite complete. There is no doubt but that it is a river clam, though I did not attempt to identify the species. Why it should have lost its structure and have been replaced by a cast I do not know. The specimen is now at the University of Kansas, with other shells from the walls.

Sincerely yours,

S. W. WILLISTON.

Criticism by Professor Todd.

Prof. N. H. Winchell,

Dear Sir: I thank you for the courtesy shown me in asking that I should criticise in any way your able paper in reply to professor Chamberlin. I regret that it has come to hand when I have not had time to do the subject justice and yet return it in reasonable time for publication. I can only briefly express some of the opinions I hold on the various questions raised, without presenting very clearly my reasons for the same.

The frequent gradation of the till into stratified drift and that in turn into loess, both laterally and vertically, I concede cheerfully, but loess, so far as I have observed, very rarely contains pebbles or erratic particles larger than half a millimeter in diameter. Particularly is this true remote from glacial moraines. Moreover, mere composition and physical properties, such as unstratified character, presence of concretions and vertical cleavage, do not clearly distinguish it from quite recent flood deposits. The latter are more likely to have erratics of some size scattered through them.

1. The point in your paper which strikes me with the strongest novelty, is your conclusion that the terraces of the early Wisconsin stage would pass below the present level of the Missouri above Lansing. Since Mr. Upham has arrived at the same conclusion I must believe there must be some reason for the view, though I cannot see it. I know of no other evidence of a crustal change which that would involve, no overlapping deposits, changes of drainage or warping of upland levels.

Your interpretation of the terraces recorded in my bulletin, No. 158, is not in harmony with my conception of their relations. Perhaps I should say right here that the terrace at Vermilion is not truly a river terrace but a till terrace formed by the ice-sheet in the valley of the preglacial stream. It is only lightly veiled with aqueous deposits. With reference to the other examples, in the first place, we are to expect that all formed in the early Wisconsin stage must fall into one strictly graded series. Some may mark the ordinary stage of a stream when the Altamont moraine was forming, these are likely to be stony especially if they are near the level of the bottom of the stream near the moraine. Those noted by Wilder and Upham, if Wisconsin, may be of this kind.

Others may mark the flood stage when the ice was receding from the moraine. To this class I would refer the higher terraces of the "Lower Bouldery series," which are stony in the vicinity of the moraine in Dakota, but are composed of fine material further away. These we should expect would be built largely of sediment, more marked in broad reaches of the valley and higher below the entrance of prominent tributaries.

Since my study of Missouri I have found no difficulty in continuing the series through that state to the narrow gorge below Booneville where we should scarcely hope to find them preserved if ever formed. It should be remembered also that another moraine as we may call it, though it has several members, was formed somewhat later in the Wisconsin epoch, the Gary moraine. It would be expected that a lower series of terraces might be found less prominent perhaps corresponding to the recession from that moraine. Such was the conclusion reached and published in the Missouri Geological Report, vol. X, pp. 216-17. The correctness of these conclusions may be judged from a consideration of the following terraces arranged in series according to this view, with the hights of each above the ordinary level of the river adjacent. Their locations and relations to the river may be learned from a map and from the U. S. Geol. Survey bulletin, No. 158 and from the Missouri Geol. Report, vol. X.

Altamont stage.	*Gary stage.*
Niobrara, Neb., 180-210.	Yankton, 140.
Sioux City, Iowa, 125-150.	Blair, Neb., 90-110.
Blair, Neb., 140.	Calhoun, Neb., 100.
St. Joseph, Mo., 165-175.	Bellevue, Neb., 70.
Kansas City, Mo., 150-160.	Wyoming, Neb., about 70.
Sibley, Mo., 100.	Lexington, Mo., 70.
Lexington, Mo., 140.	"Tete Saw plains" 70-90.
Brunswick, Mo., 150.	Jefferson City, Mo., about 100.
Glasgow, Mo., 160-175.	
Booneville, 150-170.	

These are not all the examples which might be named, and in some cases they are extensively developed.

I visited the Lansing locality last December with some expectation that the remains might prove to have come from the base of the terrace corresponding to that shown at Kansas City, where some remains of mammals have been found. In such a case it would have been reasonably evident that they dated from early Wisconsin time. Instead I found them outside of the trough of the Missouri in the base of a deposit forming an ill-defined shoulder in the valley of a small tributary which rises twenty-five to thirty-five feet above the flood plain of the Missouri. It is reasonable to account for the indefiniteness of the shoulder by wash added from the hillside back. The deposit there is of a grayer tint than that upon the hills back, which is rusty and sandy, resembling that on the east side of tne Missouri in this latitude. The bouldery drift is very thin. It is probable that the ice sheet never reached quite so far as this. It seems possible that the pre-glacial valleys were never perfectly filled in the loess stage, whether it was Iowan, Illinoisan or late Kansan, and that the water ways were revived along the same lines as before. Then followed a period of rapid erosion of the Missouri valley and a deepening of its tributaries much beyond any former trenching, another filling to the hight of the terrace outlined above, and again excavation of the sediment, which may not however have extended far up the tributaries. We might think the deposit under special consideration to have dated from such a stage, were it not so near the present level of the river. As it is, it seems to me altogether more rational to consider it the extended apex of an alluvial cone, or the "handle," so to speak, of an alluvial fan formed by the creek when the Missouri channel was on the east or opposite side of its flood plain. I could refer to several such deposits in Fremont and Mills counties, Iowa, some rising to fully as great a hight above the Missouri. Then the return of the Missouri to the west side would result in the cutting down again of the tributary as it is today. Nor would it require more than a few centuries to accomplish such a cycle, under favorable circumstances.

2. The evidence in favor of a deep preglacial valley seems to me hardly complete. The fact that the bottom of the trough of the Missouri opposite has been reported ninety feet below the water level does not prove that the river has ever been lower than at present. Scour to that depth has been observed at Nebraska City by Mr. L. E. Cooley, in 1879.*

The well twenty-four feet deep reported by Mr. Concannon is the strongest evidence, but is it possible that soft shale underlies the limestone there?

3. When I visited the locality there was a narrow tunnel running with the main one, and west of it extending north from the cross tunnel. As it is not hinted at in Chamberlin's paper and you say nothing of it I judge that it has been dug more recently, possibly to obtain earth to close the cross tunnel. Its bottom shows an abrupt drop in the surface of the rock floor of about two feet. How would that affect

* *Report of U. S. Engineers* for 1879-80, part 2, pp. 1066, 1071.

the geest hypothesis? Would geest be likely to have so abrupt surface under it? I confess that I did not think of geest when I was there. I did not observe much contrast in color or texture from top to bottom except that there were more stony fragments below as one would expect from a waterlaid deposit near a slope of Carboniferous limestone and shale.

From our former correspondence and conversation, you will not be surprised at my view. I have not attempted to answer all your strong arguments, but have tried rather to improve the opportunity you have so kindly given me in presenting briefly my humble contribution to the interesting questions involved.

Yours very respectfully,

Vermilion, S. D., March 7, 1903. J. E. Todd.

Note from Professor Wright.

Oberlin, Ohio.

Prof. N. H. Winchell,

Dear Sir:—I visited the Concannon farm and made my examinations soon after you were there the second time, but I did not have opportunity to make the minute observations which you are able to report. So far, however, as I was able to form conclusions, they agree essentially with those presented in your paper on "The Pleistocene Geology of the Concannon Farm." I followed down the main tributary valley all the way from its head, to its opening upon the Missouri valley close by the tunnel in question, and followed around the head of the smaller valley which joins the main tributary at right angles to it just west of the Concannon house. From these observations it seemed perfectly clear that very little rock erosion had been accomplished by these tributary streams subsequent to the deposition of the general covering of upland loess. They have done scarcely more than to remove from the pre-Iowan, (or as I think the pre-Glacial) valleys the loose material which has been carried into them during Glacial times.

This is specially clear, as you have pointed out, from the character and extent of the depression immediately in front of the tunnel and extending from the point A in your figure to the edge of the Missouri flood-plain, but which is now filled with loose debris. The stratum of limestone surrounding this depression and forming the floor of the Concannon tunnel is compact and about six feet in thickness. The depression has every appearance of being formed by the recession of the waterfall where the limestone was underlaid by shale. From considerable familiarity with the recession of waterfalls in similar conditions since the Iowan epoch, it is impossible to believe that this small stream would not have required many times the period which has elapsed since then to accomplish its work. I can but regard it, therefore, as pre-Iowan, and for the most part pre-Glacial.

2. There is no evidence that the water of the Missouri has been higher than it is now since the flooded condition of the Iowan epoch.

I agree with Mr. Upham in believing that the Wisconsin terraces disappear under the present flood-plain long before reaching the latitude of Lansing.

3. The remnant of loess-like sediment in which the tunnel is dug is in a protected place at the point of a ridge forming the bluff of the Missouri valley bounded on the west by the small tributary gorge joining the main tributary at right angles. The situation is one where a portion of the general sedimentary envelope would be protected from the erosion of these small tributaries, but where it would be impossible for it to accumulate by creep or wash from higher elevations. The least which can be supposed is that provided for in professor Williston's explanation, which involves general deposition on the margin of the Missouri when it was flowing fifty feet higher than now. But

4. The character of the lower three feet of the sediment in the tunnel in which the skeleton is said to have been enveloped, as you have described it, is such that its accumulation must have preceded the entire period of loess deposition.

My only doubt has been as to the exact position of the skeleton with reference to this pre-loessial portion of the deposit. I notice in Mr. Upham's account that he says "the skeleton was imbedded in the upper foot of a stony and earthy debris that appears to have fallen from a closely adjacent outcrop of Carboniferous limestone which also in a heavy bed forms the floor of the tunnel; or perhaps the bones *lay in a slight hollow* of the debris." I should like a little more specific information as to whether the skeleton was really enveloped in the pre-loessial deposit or simply lay in a hollow on top of it.

G. Frederick Wright.

APPENDIX B.

It was through the renewed courtesy of Mr. J. V. Brower, president of the Quivira Historical Society, that the writer made recently his third visit to the Concannon farm. He spent two full days at that place, and was accompanied and aided by Mr. Joseph Concannon in making some observations on the walls of the tunnel and on the river bluffs above and below the farm. These observations are more in detail than any that had been made before by the writer, and they serve to elucidate more fully the geology of the place as sketched above. Subquently Mr. Michael Concannon furnished the photographic print seen in plate XVIII, made from a negative taken by Mr. M. C. Long, showing the face of the tunnel prior to the work done by Mr. Fowke.

At nine places detailed sections each carrying about four feet were made of the west wall of the tunnel (Stations A to

I), with sketches and descriptions, as given below; excavations were made into the terrace and pseudo-terraces below the house, and into the loess at points south from the house, up the little tributary creek. Several samples were secured for microscopical examination.

The walls of the tunnel.

The floor of the tunnel dips toward the north or northeast, about one foot in thirty feet. Hence the floor of the entrance is about two feet lower than the floor at the further end of the tunnel.

Station A. The first examination was made at the entrance. The different parts of the material penetrated by the tunnel are numbered as heretofore. The diagram seen in Fig. 1, Plate XVII, illustrates the structure at the entrance, drawn to a scale. It has the following description.

No. 1 is divisible into 1a and 1b, the former at the bottom. No. 1a is twelve to fourteen inches thick, composed of angular debris of Carboniferous limestone and shale, not much rotted, but mingled with finer materials of loess-like color and appearance. No northern drift seen; not geest. The surface of the limerock is a little below the floor.

No. 1b, about two feet thick, is more sandy and loam-like, containing loess-kindchen and pieces of limestone. In the upper ten inches, and faintly in the lower portion, are indistinct signs of horizontal assortment or structure. Some limestone pieces are four to six inches in diameter.

No. 4 is a distinct silt stratum, two and one-half inches in thickness, and runs over the foregoing intact to the very door of the tunnel, with disturbance of continuity only at the very northern end where late weathering may have worn it off. The transition above and below No. 4 is sharp and sudden, as evidenced by the change of color, texture and evident composition.

No. 2, extending to the roof, shows here no noteworthy feature, having the aspect of ordinary loess. Its microscopic characters have already been given.

Station B. The next examination was made at sixteen feet from the entrance. At this place the tunnel is enlarged two and one-half feet in each direction, causing a rectangular shoulder in the wall. The diagram shown in fig. 2, plate XVII, consists of two parts. That on the right represents the shoulder in the west wall, facing south. The remainder shows the continuation of the west wall of the tunnel.

In the south-facing shoulder the layer No. 4 is seen to thin out to a point and disappear in No. 2, at the same time rising slightly toward the west, and not perceptibly toward the south.

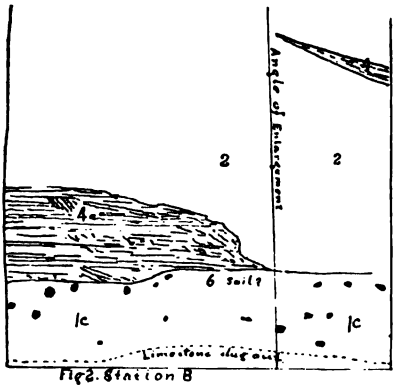


Fig 2. Station B

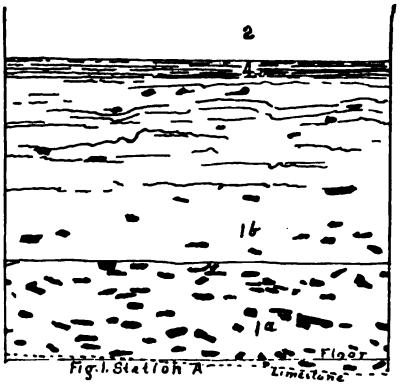


Fig. 1. Station A



Fig 4. Station D

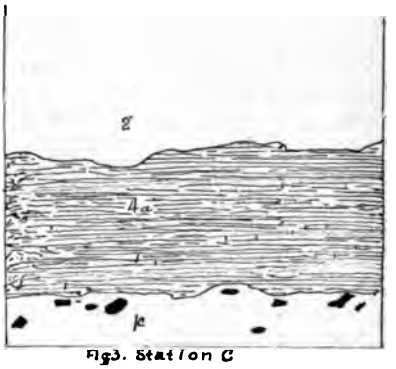


Fig 3. Station C

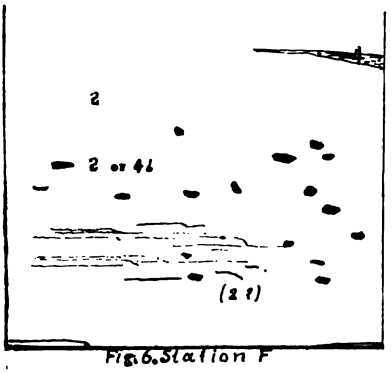


Fig 6. Station F

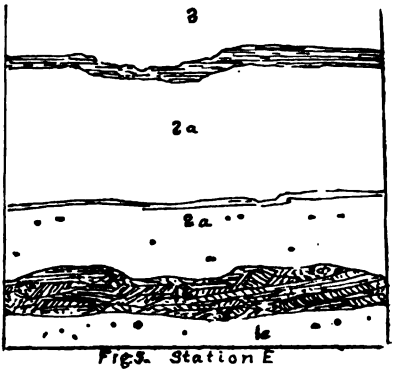


Fig 5. Station E



Fig 7. Station G

EXPLANATION.

Fig. 1. Section of the west wall at the entrance.

Fig. 2 Section of the west wall, 16 feet from the entrance. The right hand portion represents the south facing wall at the enlargement of the tunnel.

Fig. 3. Section of the west wall at 25 feet from the entrance

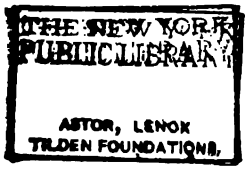
Fig. 4. Adjoins fig. 3 at the south.

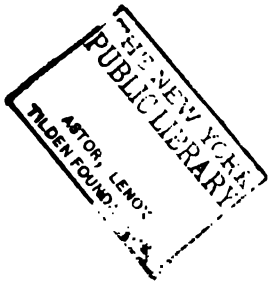
Fig. 5. Section of the south wall at 36 feet from the entrance.

Fig. 6 Section on the north wall of the Fowke tunnel, 50 feet from the entrance.

Fig. 7. Section of the face of the tunnel at 83 feet from the entrance

Sections include 4 feet vertical from the floor upward, Scale ½ inch = 1 foot.


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4a. At the same time, with a slight swell upward in the limerock floor, begins another horizontal layer, differing in appearance from No. 4, and thicker, and with a gentle southward ascent. This looks more like Carboniferous shale, but it is not in place as shale, and its lamination is somewhat disturbed. Its composition may be very much that of shale. The commencement of No. 4a is two feet below the general level of No. 4. There is therefore an open interval between the two through which No. 2 seems to come down onto No. 1c.

No. 1c. Underneath No. 4a is the continuation of No. 1a (or its stratigraphic analogue) of station A. But here it appears quite different. It is about eight inches thick, and it suggests by its dark color that it is stained by carbon and iron, perhaps also by manganese, as if it had been an ancient geest soil. In this the small limestone fragments, so far as can be seen, are much rotted and roughened by decay, quite in contrast with the condition of those in No. 1a of station A. What the manner of transition may be from No. 1a to 1c could not be seen* readily, but it is to be presumed that No. 1a disappeears coincidently with No. 4 or grades into No. 2 above No. 4a.

Sample No. 6 was taken from the darker part of No. 1c, at the point indicated.

No. 2 appears homogeneous and loess-like, rising to the roof of the tunnel.

Station C. This station is twenty-five feet from the entrance. It is illustrated by fig. 3, plate XVII.

Here No. 4a is sixteen to twenty inches thick, and its upper and lower surfaces undulate. It is nicely horizontally laminated, but at its southern limit, in this station, the laminæ are somewhat disturbed.

Sample No. 7 illustrates this member at Station C.

No. 1c is red or brown-red, and only four or five inches thick. Its color contrasts with the light clayey color of No. 4a. It lies directly on the limestone, and near its upper surface are masses of much rotted limestone.

Sample No. 8 is from No. 1c; sample No. 9 is a rough and rotted limestone piece four inches across, from No. 1c.

Station D. This adjoins station C toward the south

Here No. 4a becomes confused and thinner, and while it lies distinctly and continuously on No. 1c at the bottom its upper surface descends to the south, causing it to run to a point so that No. 2 again comes in contact with No. 1c. Angular pieces of No. 4a are mixed in the bottom of No. 2, showing some disturbing action that brought on No. 2.

Station E. Thirty-five feet south of the entrance.

No. 1c here is thin, say four inches, and is overlain by No. 4b.

No. 4b consists of debris from No. 4a, and of limestone pieces not so much rotted as generally in No. 1a, and of debris of much finer

* The wall of the tunnel was hid by boxes which had to be removed in order to get these sections.

grain not aggregated into distinct lumps or fragments but in form of powder resembling loess, but perhaps from No. 1.

No. 2 in its lower part, here, exhibits interesting features; and as it differs from No. 2 elsewhere it may be distinguished as 2a. It resembles, in general No. 2, but has thin bands of debris of No. 4a lying horizontally for two feet above No. 4a. These bands also are more calcareous, and amongst them is fine charcoal lying in short horizontal streaks, also rotted limestone pebbles. These horizontal bands are perhaps of the same origin and nature as the original No. 4 at the entrance, and were undoubtedly taken as such by the party who last August levelled along a thin silt layer from the entrance to the further end of the tunnel by setting pegs that could be seen in continuous line. In that case they can be considered as the southward continuation of No. 4.

Station F. This station is about fifty feet from the entrance, at the junction with the Fowke trench. The Fowke open trench becomes a tunnel as it approaches the main tunnel. This station is on the wall of the Fowke tunnel facing south.

No. 1c is invisible, apparently wanting, or grades upward into characters like No. 2. On the floor, in place of No. 1c, are many small rotting limestone pieces and debris of No. 4a, but mostly a finer debris like No. 1.

No. 4 appears here to be represented by a silt seam three feet above the floor which pinches out in fifteen inches to a point, with a slight upward slope toward the west, in the same manner as seen at Station B.

No. 2. Above this silt seam is characteristic No. 2. Below this seam is apparently the same as mentioned at Station E as 4b, but quite coarse and confused by rotting limestone pieces. It is difficult to distinguish No. 4b from No. 1a, and it is perhaps simply a condition of No. 1a.

According to Mr. Michael Concannon an artificial chert chip was found by him, when, in company with professor H. T. Martin of Lawrence, Kansas, he was digging in the vicinity of station F, or a few feet further south. It was lying in the member 2 or 4b. It was seen by professors Martin and Chamberlin, and was classed with the skeleton as to age and significance. At station F a red quartzyte boulder was found by Mr. M. Concannon, five or six inches in diameter, about twelve feet from the skeleton amongst the debris of limestone near the bottom, lying in No. 2 at the place where No. 1c is wanting; and Mr. Jos. Concannon found another, but smaller, at four or four and a half feet from the floor near the same place or a few feet further north.

Station G. Eighty-three feet from the entrance. Thirteen feet south from the skeleton the tunnel as left by Mr. Fowke is here represented.

At the bottom is horizontally laminated Carboniferous shale in place (sample No. 10) with an undulating upper surface, descending so as to hardly appear at the east side. Its greatest thickness is about eighteen inches.

No. 1 here contains many limestone masses three or four feet across, and smaller ones, but the bulk of it especially in its upper part, is of the reddish brown geest. From the Carboniferous shale *in situ* to an imaginary separation line between Nos. 1 and 2 is four feet, more or less, increasing and rising to the roof of the tunnel in the angle of the roof and wall. Indeed, without minute examination it has the appearance of rising to the summit of the arch of the tunnel at this place. This member has thus greatly thickened between Stations F and G.

The most of the offset tunnel running east from near this place is cut in No. 1. No. 1 here is called "joint clay" by the Concannon brothers, in allusion to the vertical jointage by which it is marked, along the openings of which calcareous water has descended from above depositing a white effervescing coating. This light coating forms a conspicuous contrast with the reddish-chocolate color of the geest.

The place of the skeleton.

Considerable effort was made on the occasion of this visit to ascertain with certainty the position of the skeleton and the nature of the materials in which it lay. I went twice with the brothers to the end of the tunnel expressly for that purpose, and made two more stations (H and I) with descriptions dictated by them, but as I received subsequently the photograph made by flash-light by Mr. Long, it is far better to discard stations H and I and substitute for them the reproduction of the photograph seen in plate XVIII.

This view (plate XVIII) was taken at seventy-two feet from the entrance. The members which it discloses at this place were removed by the work of Mr. Fowke, and it is impossible to get samples from the exact place at which the skeleton lay. However, in the light of the foregoing descriptions the parts can be identified and numbered. The place of the skeleton is indicated by the horizontal white spot at the right and slightly above the hat. The dark spot at the left and above the hat shows a rotting large piece of limestone. The strati-

fied substance 4a on the plate may be Carboniferous shale *in situ,* but as it shows rather too much dip and as no shale appears at the nearest point in the wall it may be 4a of the foregoing stations. In the latter case the designation 1c is the lowest geest stratum. In any case the mass of the geest is above 4a and the skeleton lay in or on it, some of the limestone slabs of the geest lying at a little higher level than the skeleton. In No. 2 are scattering bits of charcoal, and some land shells, viz: Polygyra exoleta, Pyramidula alternata costata, Polygyra monodon fraterna, and Pyramidula perspectiva, and fragments of small bones.

The bluffs of the Missouri river.

The writer made examination of the river bluffs above and below the Concannon farm. There are five benches, four of which might be mistaken for alluvial terraces, numbered from below upward.

These are all more or less continuous both above and below Concannon's, but Nos. 1, 3 and 5 are distinctly marked and level.

Level No. 1. By excavating in No. 1 it was found to consist of fine sandy alluvium appearing clayey when wet. It covers the place of the stratum of limestone that forms the floor of the tunnel. It was at first suspected that its existence was due to the persistence of that stratum, but that idea was abandoned after several pits had been sunk in it, and on observing that at no point, for three quarters of a mile below, nor for two-thirds of a mile above, does that limerock appear in any of its angles. This terrace is well shown in professor Chamberlin's photographic figure No. 6 (p. 757), running but little above the grade of the railroad. Its level is fifteen to eighteen feet above the bottom land, or thirty feet above low water. Its width is twenty to forty feet.

Level No. 2, is irregular and hummocky as to upper outline and suggests a slip origin. It rises twelve to fifteen feet above No. 1 and its width is about twenty-five feet, but in spots it is wanting, the ground sloping up from Level No. 1 to No. 3. Large fallen masses of limestone more or less disintegrated lie on the surface, or are buried in soil and vegetation. From this bench to No. 3 is a sharp ascent to No. 3, which latter shows

limestone bedding along its crest. Several pits were dug in Level No. 2, and their testimony united with that of the stony and hummocky contour to prove that No. 2 is due to talus masses fallen from No. 3. It is older than Level No. 1, as the masses from No. 3 do not lie on No. 1 but continue as a lower talus below No. 1. This was revealed in pits dug in No. 1.

Level No. 3 is manifestly due to the strike of firm beds of the Carboniferous, underlain by shale. This shale is that which appears in the tunnel and was excavated in the foundation and cistern of Mr. Concannon's house. The firm beds cause a bench running back from the house, and have been quarried on the north side of the creek. This bench is about twenty feet wide, but its upper surface back from the brink is apt to be hummocky, same as No. 2, thus constituting Level No. 4. Hence No. 3 is a residual terrace. It runs out just back of Concannon's house, swinging up the creek valley where it also is dimly outlined on both sides.

Level No. 4 is fifteen to twenty feet higher than No. 3, and is plainly due to talus debris from level No. 5. It shows outwardly all the characters of No. 2.

Level No. 5 rises about 100 feet above No. 3, and at some places, say a quarter of a mile below Concannon's, the whole cliff can be seen to consist of Carboniferous rocks, thus:—

Sandstone.

Limestone.

Shale (black, worked at one point for coal.)

This upper limestone has also been considerably quarried on the north side of the creek.

There is therefore but one alluvial terrace. It rises perhaps two feet above the floor of the tunnel. It is persistent and perfect as to outline and composition. It can have had nothing to do with any supposed terrace or floodplain rising to the hight of twenty-five feet above the limestone floor of the tunnel. It is evidently quite a recent formation, and it is reasonable to suggest that it was formed by the waters of the great flood of 1844. Its average upper surface is perhaps two feet below the place of the skeleton.

There is no appearance in the bluffs of any recent "truncation" by the river; but every element in their form and composition implies great age and gradual demolition under the

action of atmospheric forces. The writer has never seen, within the limits of the Wisconsin drift areas, an instance of vertical cliffs demolished in this step-like fashion to such a degree of irregularity by atmospheric forces. Such weather effects require more time, and here they probably date from pre-Iowan glaciation.

Other digging.

It had been planned to make some excavation in the loess of the surrounding region with a view to comparing the loess at the Concannon tunnel with the general loess deposit, but the time available would not permit a satisfactory test of that kind. However two pits were dug about six feet deep.

One pit was toward the south up the valley of "the little tributary creek." It was in the surface of a small flat area, about twenty or thirty rods south of the house but on the west side of the creek where no rock or rock debris could be seen, appearing like an ancient terrace level of Iowan date. Its hight was approximately 100 feet above the bottom land of the river. A trench, or trench-like pit, was dug in the brink of this supposed terrace. The soil was found rather thin, grading down into a homogeneous sandy loess without structure, pebbles or limestone debris, but with black bits that appeared like charcoal, but may have originated underground by carbonization of roots or other wood without having been burnt at the surface. Throughout this pit were tubules, but no sign of lime. Iron crusts and small iron balls and perhaps some manganese stains were seen in it, of which the irregular distribution caused a slightly blotched appearance. This pit was above the level of the limestone forming Level No. 3 foregoing.

Another pit was dug about ten rods from the house and about on a level with the bottom of the limestone forming level No. 3, also in the west side of the valley of "the little tributary creek," about thirty or forty feet above the floor of the tunnel, and about ten or twenty feet above the "little relic-bearing deposit." This trench was dug six and a half feet deep. Within the last three feet we found much limestone debris, coarse and fine, loess-kindchen and one rounded white quartz pebble, three-quarters of an inch in diameter. The material passed through below the soil (18-24 inches) was first loess-like and

similar to that in the other pit, but it became not only limy, with debris from limestone and with loess-kindchen, but also much more light-colored, almost light yellowish, and finer-grained acting like putty. The coarser material was plainly much rotted, but also apparently originally water-worn. In this pit therefore, though not in all its features, nor in so pronounced a condition, we have essentially the repetition of Fowke's trench. We saw no stratification, but in the bottom is apparently the talus lying on the bedrock, with a darker band, gravelly and calcareous, which is apparently the analogue of the dark band overlying the geest in the tunnel. We did not actually reach the bedrock, but stopped amongst fallen limestone masses some of which were about three feet long.

If it should be desired to further demonstrate the wide extent of the "little relic-bearing deposit," it will be necessary to make further testing of the loess in the vicinity. The testing above mentioned is not deemed sufficient to complete such demonstration.

Further microscopical examination.

Samples were collected as follows, including those already mentioned.

No. 1. On the floor of the tunnel near the point where the skeleton was found, but to the eastward, i.e. at the entrance of the offset tunnel, supposed geest, enclosing rotting limestone masses.

No. 2. Loess from the wall of the tunnel about seventy feet from the entrance, above the horizontal silt layer.

No. 3. Loess from the roof of the tunnel, at about seventy feet from the entrance.

No. 4. From the silt layer at the entrance.

No. 5. Laminated loess, St. Joseph, from the foot of a remnant of a high spur of loess, between the depot and the river, perhaps a few feet below the railroad grade.

No. 6. Concannon tunnel, station B, to illustrate the darker part of No. 1c.

No. 7. From No. 4a at station C.

No. 8. From No. 1c at station C.

No. 9. Rotted limestone piece four inches across from No. 1c at station C.

No. 10. Carboniferous shale at station G.

No. 11. Fine sandy loess without structure, at twenty or thirty rods south from Concannon's house, and about 100 feet above the bottom land, three feet from the surface.

No. 12. From the same pit as No. 11, at five and a half feet below the surface; similar to No. 11.

No. 13. Fine yellow clay, putty-like, from a pit dug ten rods south of Concannon's house on the west side of the tributary ravine, about thirty feet above the floor of the tunnel, about four feet below the surface.

No. 14. More coarse and gravelly clay from the same pit at five feet below the surface.

No. 15. Loess-kindchen, white quartz pebble and rotted limestone pebbles, from the same pit.

No. 16. Much lighter yellow clay, from the bottom of the same pit as No. 14.

No. 17. Rotted, brownish spot, having the form of a pebble, from the wall of the Fowke tunnel.

No. 18. Land shells, fragments of small bones, a small tooth, and bits of crinoid stems, from limy loess (No. 3) in the main tunnel.

No. 1. The principle element in No. 1 appears to be irregular, small shreds and scales of kaolin. The substance does not, as a whole, appear scaly, but it is unctuous and very fine. Its color is of gray or reddish, according to the distribution of iron oxide. A few isolated scales are large enough to show a biaxial optic axis as interference figure in comergent light. Its refactive index is markedly higher than that of the balsam. In numerous instances the larger scales appear to be charged with bubbles and ferruginous impurieies. Between crossed nicols this kaolin is almost entirely dark, brightening up a little when the converging lens is turned on. Besides kaolin and the coloring material, a very rare angular small quartz grain can be seen. No. 1 seems to be almost a pure clay.

No. 2, when washed and decanted shows numerous grains of quartz and feldspar, occasional hornblende, biotite and magnetite.

No. 3 is similar, or identical, with No. 2.

No. 4, while consisting largely of small composite grains from No. 1, contains a considerable amount of quartz, the grains of which are usually rounded.

No. 4a is microscopically indistinguishable from No. 1.

No. 5, when its grains are isolated, is found to consist largely of drift materials, mostly angular quartz, but with a liberal amount of kaolin in agglomerated scales and composite grains.

No. 6, which is the upper part of No. 8, is evidently sandy and iron-stained. On washing, in order to separate the

coarser grains, the sandy element is found to consist chiefly of debris from limestone, fragments of fossils, small crinoid stem joints, and rounded white quartz grains. There are also some small rusty sandstone fragments, and fragments of sandy shale. The coloring element is bog ore.

No. 7 cannot be distinguished microscopically from No. 1.

No. 8 is like No. 6, but the iron is more evenly distributed, producing a general rustiness rather than bog ore. Some of the quartzes are purplish, as if from the Potsdam quartzyte of South Dakota, indicating a derivation since the Kansan drift was spread. One microscopic cinnamon-garnet was noted in the washed sand.

No. 10. Carboniferous shale. Microscopically this is identical with No. 1, and with No. 4a, and shows the source of those members.

Inferences from the microscopic characters.

It is evident from the foregoing that there is not a uniformity in the characters of the substance lying on the limerock floor. The same is apparent from the descriptions of the stations above. At the entrance the limerock is first covered by a stony debris (1a) mixed with loess, both resulting doubtless from recent dislodgment from above. At sixteen feet from the entrance this is replaced by a rusty sandy stratum about eight inches thick (1c) made up of angular limestone sand, corroded residue of fossils from the Carboniferous, rounded quartz grains and small bits of rusty shaly sandrock containing also much rounded and rusted and corroded small masses of limestone. This continues beyond thirty-five feet but is apparently wanting at fifty feet from the entrance and does not certainly reappear at seventy-two feet. This is evidently a waterlaid substance, the assorting action having been sufficient to carry away the most of the clayey ingredient had it been present. The bog ore which in part characterizes its upper portion indicates surface exposure, but not necessarily a condition of humus. At fifty feet the first substance over the rock floor seems to be of the nature of No. 2 (loess) but probably with a large ingredient from No. 1. At eighty-three feet from the entrance the limerock passes under Carboniferous shale *in situ*. The composition of No. 1c denotes post-Kansan origin. The presence in No. 1c of considerable rusty sandstone.

and sandy shale, which is derived from the sandstone overlying the highest limestone in the region, indicates that that sandstone was easily accessible to ordinary weathering, a condition which implies, again, that the Iowan loess had not yet been deposited, since the loess, now effectually protects it from weathering and wash.

That which overlies No. 1a and 1c also varies. At the entrance it is No. 1b, which is an imperfectly water-assorted and water-laid pebbly, or even stony, loess, with loess-kindchen. In No. 4, at the entrance, the presence of standing water is plain. No. 1b was deposited in flowing water, and in such abundance that it was not completely stratified. When No. 4 was deposited the water was dammed, and the supply of solid matter had waned or temporarily ceased. At sixteen feet from the entrance (station B) the silt layer lies distinctly in a material (No. 2) which was not differentiated below that layer at the entrance, but a mass of shale from the Carboniferous here appears at a lower level, lying on No. 1c in such a manner as to show that the shale is not in place. This shale has been taken, perhaps by some observers, as a stratum analogous in origin, though about two feet lower, to the silt layer (No. 4). Its microscopic composition is so different from that of No. 4 as to exclude that idea. It is rather a part of the Carboniferous shale that has slid from its parent mass and run over on No. 1c. The somewhat disturbed condition of its laminæ agrees with the hypothesis of such displacement. No. 4 carries some quartz in rounded grains. No. 4a has none but consists of the elements of clay or geest, although its lamination shows that it was water-laid, and not land-formed as it exists at present. No. 4 carries a notable amount of carbonate of lime. No. 4a has none—or next to none.

No. 4a, lying still on No. 1c is continuous at twenty-five feet, but it soon becomes much broken toward the south and is reduced to a thin stratum at thirty feet, which continues, with disturbed lamination, to thirty-five feet. At fifty feet it is invisible, like No. 1c, and No. 2 apparently lies on the rock. In the midst of No. 2, at this place, however, are indefinite stratification lines, and No. 4 is again quite evident, about two and a half inches in thickness. No. 2 can be seen here, as at sixteen feet from the entrance, to pinch out westwardly. Here

therefore were two contemporary detatched quiet water bodies, so far as indicated by the tunnel, one about fifty or sixty feet north from the other. Was the material which subsequently covered these silted strata brought from the north or from the south? Was it borne by an influx of greater volume of water from the north or was it the product of a land-wash from the south?

At seventy-two feet from the entrance, where the skeleton was found (plate XVIII) No. 4a reappears, and over it in a mass of formless clay resulting probably from its disintegration, the human remains were discovered. This overlying material, No. 1, was from two to three feet thick, containing not only debris from Carboniferous shale but also large pieces of limestone. How much of No. 1 here was contributed by decay of limestone is uncertain, but it is safe to infer that the larger part was derived from No. 4a and from adjoining Carboniferous shale *in situ*. No. 1 shows, in every sense, the characters of geest, chemical, microscopical and structural, and its origin can be assumed to be only that which is ascribed to geest, viz., a residuum from decayed and decaying rock. It so happens here that one of the forms of the parent rock was easily disintegrated, and further possessed, prior to disintegration, essentially the composition of geest, and that, hence, the chemical transformation was less, and the product of geest was greater.

At eighty-three feet from the entrance (station G) the characters of No. 1 extend from the Carboniferous shale nearly to the roof of the tunnel, having a thickness of about five feet.

The result of this special examination is, as should have been expected, the restriction of the geest practically to the last fifteen to twenty feet of the tunnel. In this geest has been found no drift pebbles, nor quartz sand, nor valley wash, nor heterogeneous mixture. It is wholly referable to the underlying rock. The most of the contents of the silt layer was undoubtedly derived from this geest, as it contains so large a percentage of kaolin, undistinguishable from it. Had the Iowan loess been present to supply material for this silt it would probably have approximated more nearly to the loess in its composition.

After the deposition of the silt, by wash from the geest and from the Carboniferous and from the Kansan drift, the action

of the Iowan ice epoch supervened, resulting in the filling of the Missouri valley with the Iowan loess and its abundant waters.

That "the little relic-bearing deposit" which contains so much limestone debris was formed when the limestone was uncovered, and by an agent that came into contact with it, is evident. The little creek at no place comes into contact with the Carboniferous limestone above the point A of figure 2, and that point is too low to have furnished this debris, by any agent. At no higher point is the limerock uncovered so that any agent could get access to it, but loess covers it deeply, even on the summit of the bluff back of Concannon's. It appears a necessary inference, therefore, that the limestone debris was accumulated cotemporary with the formation of the loess which now covers it and encloses its fragments.

PLATE XVIII.

View of the face of the tunnel at 72 feet from the entrance, showing the position of the skeleton with reference to the various members of the "Stations" of plate XVII. The white horizontal spot "at the right of the hat shows where the bones lay, in fine grayish colored material."—*M. Concannon.* The dark spot above and at the left of the hat shows a large limestone mass. The material 4*a* is probably Carboniferous shale not much disturbed, but perhaps slid from its place and overlying a layer of 1c. The "grayish material" in which the bones lay, judging from the gray material left in the angle of the wall where the Fowke tunnel to the east was begun was a mixture of shale and fine limestone gravel, quite compact, impervious and vertically jointed, like much of No. 1, evidently a more immediate product of the disintegration of the shale than any other part of the face of the tunnel.



INTERIOR OF TUNNEL.
Hat indicates where skeleton was found.

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NOTE ON TITANIFEROUS PYROXENE.

By ALEXANDER N. WINCHELL, Butte, Montana.

It has been stated by the writer* that "so far as known this element [titanium] has no effect on the optic angle [of pyroxene], titanaugite having as large an angle as ordinary augite."

After some search the attempt to verify in the literature the last phrase of the above quotation has failed, perhaps for lack of ample library facilities. However, the whole purport of the quotation is admirably supported by the recent work of G. Becker,† who, while making primarily a chemical study, has also investigated the optic properties of a titaniferous pyroxene from the basanyte (rich in olivine, and poor in feldspar) of Kilimanjaro, Africa. Becker has apparently made very careful analysis, without, however, determining the percentages of alkalies present. His results may be tabulated as follows, with certain others introduced for comparison:

	I.	II.	III.
SiO_2.....	44 89	45 05	48.34
TiO_2.....	2.39	4.39	1.98
Al_2O_3.....	3 93	.16	2.90
Fe_2O_3	2.72	5.50	4.68
FeO.....	10.54	14.90	14.15
MnO..... .	.....	1.58	.....
MgO.....	12 79	15.15	11.34
CaO.....	22.13	10.72	15.10
Na_2O.....	.....	1.27	.....
K_2O.....	.....	.78	.....
Ignition...	.11	.13	.....
Total.....	99.50	99.63	98.49
2 E.....	118° 11′	13°—62°+	
2 Ha.....	62° 20′		
2 Va.....	60° 28′		
Spr. Gr....	3.36	3.316+	

I. Pyroxene from basanyte of Kilimanjaro, G. Becker, analyst.

II. Pyroxene from olivine diabase of Pigeon Point, Minnesota. A. N. Winchell, analyst. *Loc. cit.*

* AMERICAN GEOLOGIST, vol. xxvi, p. 208.

† GUSTAV BECKER. Zur Kenntniss der Sesquoixyd—und titanhaltigen Augite. Inaugural-Dissertation. Universitäts Erlangen. 1902.

III. Pyroxene from olivine diabase of Pigeon Point, Minn. Partial Analysis by R. B. Riggs. Bull. 109, U. S. Geol. Survey, p. 36.

The pyroxene whose composition is given under II above has been called pigeonite by the writer; it is unique in possessing an optic axial angle which is quite variable, but always distinctly less than the usual value for pyroxene. That this abnormally small optic angle is not due to the high per cent of titanium dioxide present in pigeonite seems to be quite well established by the work of Becker. In general pyroxenes possess an optic angle which is remarkably constant; angle V very rarely varies* more than two degrees from the normal value which is nearly 60°. In the three known instances* in which the optic angle shows a marked variation from the normal value it has the values: 65° 3′, 66° 44′, and 68°. These are all larger than the normal value, and the variation even here is insignificant when compared with the variation in the pyroxene of Pigeon Point, where the optic angle becomes so small in some cases as to give almost the effect of an uniaxial mineral. Another peculiarity of pigeonite is that in it the optic angle seems to be extremely variable even in a single thin section. These characters of pigeonite can hardly be due to the manganese content, since Flink* has shown that schefferite from Sweden with six to eight per cent of MnO has an optic angle of 65°.

The only two occurrences of pigeonite at present known are both in Minnesota:—at Pigeon Point, and at Duluth, that is at the two extremities of a single petrographic province. These lines have been written in the hope that they may lead to the discovery of other occurrences of this anomalous pyroxene.

* Cf. HINTZE. *Handb. Mineral*, ii, pp. 1025-1029.

BASIN-RANGE STRUCTURE IN THE DEATH VALLEY REGION OF SOUTHEASTERN CALIFORNIA.*

By M. R. CAMPBELL, Washington, D. C.

Recently attention has been called to the geologic structure of the mountain ranges of Nevada and southeastern California. An attempt has been made to show that they are generally anticlinal in structure, and that the tilted-block type which Gilbert has described, and which is generally known as basin-range structure, is of rare occurrence.

The object of the present paper is to show that, although minor folding was observed in the Death Valley region, the mountains are generally composed of huge blocks of strata that have been strongly tilted and then eroded into their present forms.

The region described is traversed by two systems of structures; one extending in a north-south direction, being the southern extension of the true basin ranges of Nevada, and the other crossing these in a northwest-southeast direction parallel with and presumably an off-shoot from the main line of the Sierra Nevada. The movements which produced these structures seem to have been preceded by an epoch of slight folding in which the Palæozoic strata were somewhat deformed. This was followed presumably in Eocene time by faulting and tilting along northwest-southeast axes which formed parallel mountains and valleys trending in the same direction as the Sierra Nevada. In the valleys so formed lakes accumulated, probably through a change in climatic conditions, and sediments having a thickness of several thousand feet were laid down. In these lake beds are the great deposits of salt, gypsum, soda, and borax, which have made the region famous. Following this period of sedimentation came one of movement along north-south axes, which lifted and tilted the surface into immense mountain ranges trending parallel with the new axes. Panamint, Death and Amargosa valleys were thus formed, and Funeral and Panamint mountains were raised up between

* Abstract of a paper read at the Washington meeting of the Geological Society of America, Dec., 1902.

them. Lakes formed in the new valleys and received sediments similar to those of the preceding period.

The age of the second lake-forming period is vaguely referred to late Tertiary. From structural and stratigraphic evidence the beds are younger than the lake sediments of Death valley, and they are certainly older than the gravel deposits which mark the Pleistocene period in this region; therefore, they are provisionally classed as Miocene and younger.

EDITORIAL COMMENT.

HOW LONG AGO WAS AMERICA PEOPLED?

To glacial geology, as much as to archæology and ethnology, must we look for the answer of this question. On this continent, glacialists find evidences of man's presence only during the late and closing stages of the Ice age; but the Old World has good proofs that man was there, making and using stone implements, contemporaneous with the oncoming of that age, when an ice-sheet enveloped the northern half of continental Europe and the greater part of the British Isles, reaching south to the upper courses of the Don and Dnieper, to the lower Rhine, and to the Thames. Any estimate of the antiquity of man, therefore, whether in the western or the eastern hemisphere, must depend on the measures or estimates obtained by geologists for the duration of the Postglacial period, and of the much longer Glacial period.

For the time since the end of the Ice age, apparently nearly alike in America and Europe, approximate determinations have been given by N. H. Winchell, G. F. Wright, and many other glacialists, as summarized by Hansen, which range from 5,000 to 12,000 years. Their average, or about 8,000 years, may be confidently accepted as near the truth.

It is more difficult to secure a probable estimate, on which glacialists will so well agree, for the length of the Glacial period, which is found on both continents to have been very complex and long, as measured by years, though short in comparison with preceding geologic periods. On both these vast land areas it involved nearly the same sequence in the stages of

growth and decline of the ice-sheets, in their first accumulation, great recessions and readvances, and their final melting away. From the beginning to the end of the glaciation are counted several stages or epochs of growth and wane, the principal times of ice advance and deposition of drift sheets and moraines in North America being named the Albertan, Kansan, Illinoian, Iowan, and Wisconsin stages.

Some glacialists have estimated the antiquity of the Kansan stage of glaciation, when the ice-sheet extended farthest on the west side of the Mississippi, as from fifteen to fifty times as long ago as the end of the Ice age, that is, between 100,000 and 400.000 years ago, while the Albertan stage and the beginning of the ice accumulation were still older. Others, however, recognizing the necessary limitations of the whole time of life on the earth, from the very ancient Algonkian period until now, considered by astronomers and physicists to be perhaps only about 20,000,000 years and quite surely no more than 100,000,000 years, and comparing the somewhat well known ratios of the geologic eras and periods, have concluded that the portion of time belonging to the relatively very short Glacial period, in all its stages, cannot exceed 100.000 years.

Such a measure of this period would place its Kansan stage some 50,000 to 25,000 years before its end; and the Iowan stage, to which the fossil man of Lansing, Kansas, is referred, would be only 12,000 to 15,000 years ago. These estimates seem to me compatible with the characters of the Kansan and Iowan drift formations. Instead of the great antiquity attributed by some to the Kansan drift on account of its plentiful pebbles of decayed rock, supposed to have rotted since the Ice age, I would refer these to a much later derivation from stream gravels that had been affected during a long preceding period by subaërial decay, or to glacial erosion from preglacially weathered and decaying rock surfaces. The pebbles or eroded rock fragments would hold their form during the glacial erosion, transportation, and deposition, by being then frozen. Again, the patchy occurrence of the oldest till deposits in some places near the extreme boundary of glaciation, often found on hights but absent from lower ground, I would not refer to subsequent erosion, implying a great lapse of

time, but to originally unequal and patchy deposition, analogous with the tendency of the ice-sheet in its Wisconsin stage to add till to the hights of growing drumlins, in localities of their abundant development, while sometimes leaving little till or none on intervening low tracts of the bedrock. With these explanations I think we may accept a moderate estimate of the age of the Kansan drift, consistent with a duration of the entire Glacial period as only about 100,000 years, and with a close relationship of the Iowan and Wisconsin stages, both belonging to the Champlain epoch or time of land depression terminating the Ice age.

Man lived in the region of the Somme valley, France, before the great elevation of northern lands which caused them to be mantled with snow and ice. From the Old World, the original home of our species, mankind migrated to America at some undetermined time before or during the Ice age. If the migration was contemporaneous with the glaciation of the northern half of our continent, the passage, whether from northeastern Asia or northwestern Europe, or from both, took place along the shores of the sea, where the vast ice-sheet was bordered by a strip of coastal land like that now fringing the Greenland ice-sheet, but which has since been deeply submerged.

That America was peopled very long ago is ascertained geologically by traces of man contemporaneous with the closing scenes of the Ice age in Delaware, New Jersey, New York, Ohio, Indiana, Kansas, Iowa, Minnesota, and Manitoba. The latest and most noteworthy proof of this was the discovery last year of a human skeleton under loess of the Iowan stage of glaciation near Lansing, Kansas, as described by the present writer in this magazine last September. At least it is to be said that this is the view very confidently held by Winchell, myself, and others who have later visited and examined that locality.

But a different view is held by Chamberlin, Holmes, and others, who, from their examination of the Lansing section, think the deposit above the skeleton to be more probably referable to Postglacial time. With much care and effort they have also worked and written, during the last ten years, against all the geologic evidences, which others have thought acceptable,

of man in America in the Glacial period. While some parts of the formerly supposed evidences have been shown to be erroneous, many other observations seem to me to admit only the conclusion that man was here before the end of the Ice age, and, if so, doubtless through a long preceding time.

One of the earliest observers in this country to record traces of Glacial man, by flakes from the manufacture of quartz implements, was Winchell, in 1877, at Little Falls, Minnesota. Through twenty-five years from that date, being busy with other geologic work in the survey of this state, he was not a participant in the further investigations concerning this subject. Having been silent during the very animated discussions of the past decade, he now comes to the careful consideration of the Lansing discovery which he has presented in foregoing pages, and in his earlier address as president of the Geological Society of America, with no trammels of previous partizanship. To my mind, after much study of this new discovery, the evidence of man here in the late Iowan stage of glaciation, as so well reviewed by Winchell, seems entirely conclusive.

Ethnology likewise declares, as voiced by Powell in a profoundly philosophic paper in *The Forum* of February, 1898, that man came to America very long ago, and that he has since developed the many and diverse languages, handicrafts, legends and myths, and the physical peculiarities, of the American race. How long ago that migration took place, permitting the racial development of these people, called the American Indians, to begin, we cannot tell definitely, or even approximately, in terms of years. We can only say that before our continental ice-sheet passed its Iowan stage, the American or red race appears, as shown by the Lansing skeleton, to have progressed far in its differentiation from the white, yellow, and black races. W. U.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Schmalenseeia amphionura en ny trilobit-typ, af JOH. CHR. MOBERG. [Meddelanden från Lunds Geologisk-Mineralogiska Institution, No. 5. Stockholm, 1903.]

Dr. Moberg states that a peculiar and interesting trilobite was found in the collections of the Geological and Mineralogical Institution of the University of Lund labelled as "Limarssonia occulta" [Linnarssonia was preoccupied by Walcott for a genus of brachiopod]. The fossil is stated to have been collected from the zone *Agnostus pisiformis*—the lower part of that zone, in close relation to the equivalent of the Andrarum limestone, and so near the top of the Paradoxides beds.

The material studied shows the principal parts of the test, the middle piece of the headshield the movable cheek, the pygidium and parts of the body joint, which is carefully described by the author. The dimensions of the parts also are given, and there is a plate of figures showing the aspect of the two shields, etc. Each of the shields is from 1.5 to 1.8 mm. long, and of proportionate width.

Dr. Moberg in conclusion refers this little trilobite to the neighborhood of the Chiruridæ, but says that it does not belong to any known family.

[It appears to bear the same relation of Chiruridæ that Conophyrs does to Asaphidæ or that Achantholenus does to Anomocare; i.e. small, immature form of a large trilobite, or a trilobite arrested in its development in one of its early stages. A larval feature appears in the narrow annulated glabella, though the closeness of the eye to the glabella has an opposite meaning. In any case the trilobite is of interest as carrying down to the base of the Upper Cambrian a type hitherto known only from the summit of the Cambrian, upwards.] G. F. M.

The Glacial Geology of New Jersey. By ROLLIN D. SALISBURY; assisted by HENRY B. KÜMMEL, CHARLES E. PEET, GEORGE N. KNAPP. Vol. V of the Final Report, Geol. Survey of New Jersey; HENRY B. KÜMMEL, State Geologist. Pages xxvii, 802; with 66 plates (including four folded maps in a pocket of the cover), and 102 figures in the text. Trenton, 1902.

In New Jersey the central part of the great ice-lobe of New York and New England attained its farthest southward extension, lacking only about 200 miles of the lowest latitude reached by the ice boundary in southern Illinois, at the central and farthest advance of its wider compound lobe in the Mississippi basin. New Jersey is also of great interest to glacialists because there the varied deposits of the glacial drift adjoin the Pleistocene formations of the more southern part of

our Atlantic coastal plain, permitting the two series to be compared and correlated as to their age and conditions of origin.

Professor Salisbury, coming with a large experience of exploration of the glacial drift in Wisconsin and other states of the upper Mississippi region, has worked on the Pleistocene problems of our Atlantic border, in the intervals of other duties, during twelve years. The present volume is his report on the glaciated northern third of New Jersey. It does not proceed, however, to the desired correlation of the glacial drift with the Lafayette and Columbia formations, well studied by McGee, Darton, and others, on the coastal belt of the southern states. This chief fruitage of the glacial work in New Jersey is reserved, to be given, as we may hope, in a later report, which should treat, with ample details, of the Pleistocene series in the southern part of this state.

A general description and discussion of the drift and the Glacial period form Part I, in 226 pages. The conditions which lead to the accumulation of glaciers and ice-sheets, the manner in which they affect the surface of a region on which they lie, and the forms and disposition of their deposits, are analyzed in detail, with abundant references to the glacial deposits of New Jersey.

The remaining and greater part of the volume deals very fully with local details, describing the terminal moraine, till, striæ, kames, eskers, stratified plain and valley drift, loam, brick-clays, etc., mainly arranged under three divisions, the Appalachian region, the Highlands, and the Triassic plain.

Referring to the cause of the glacial climate, Salisbury rejects the astronomic theory of Croll, which would give about 80.000 years as the measure of Post-glacial time. Instead, he thinks it to have been a comparatively short period of 6,000 to 10,000 years, according to estimates by G. K. Gilbert and N. H. Winchell, derived respectively from Niagara and the Falls of St. Anthony.

The view that the Ice age was due to great elevation of the lands occupied by the glacial drift, as held by Dana, Upham, and Wright, is also rejected; and the submarine continuation of the Hudson river channel, to a depth of 2,800 feet beneath the sea level off the coast of New Jersey, is not mentioned, although it proves so great elevation of this part of our continent about the time of the ice accumulation.

Preference is given to the hypothesis of Chamberlin, which attributes glacial conditions to changes in the amount of carbonic acid gas contained in the atmosphere. It is thought that these changes, affecting the entire earth, and tending everywhere to contemporaneous increase or decrease of glaciation, that is, to cycles of glacial and interglacial stages on the borders of ice-sheets, are most harmonious with what is known concerning the North American and European glacial drift and the fluctuations of glaciers in mountain regions.

Beyond the prominent terminal moraine in New Jersey, scantier and older glacial drift, referable perhaps to the Kansan stage of the Ice age, is found, in quite irregular and patchy distribution, to a max-

imum distance of about twenty-five miles. Salisbury writes of this older drift as follows:

"The extra-morainic glacial drift is far from constituting a continuous sheet within the area where it occurs. A large part of the surface has no drift, and where it occurs it is often very meagre, being represented only by scattered bowlders derived from formations farther north. Thin beds of drift, two or three feet in depth, are common, while in not a few places the drift is of considerable thickness, locally as much as thirty feet.

"The lack of continuity of drift in this region is in striking contrast with the condition of things north of the moraine, where drift in greater or less thickness is essentially continuous. It is true that there are frequent outcrops of rock north of the moraine; and it is true that there are, here and there, areas of some size where the drift is thin. But the areas where the drift is very thin are much less extensive north of the moraine than south of it. The relationship may be expressed in some such terms as the following: North of the moraine, four-fifths of the surface is so deeply covered with drift as to conceal the underlying rock, and the products of its decay; south of the moraine and north of the drift limit, four-fifths of the surface is nearly free from drift. Just as the one-fifth north of the moraine has occasional bowlders and small patches of drift, so the four-fifths of the area south of the moraine, and north of the drift limit, has occasional bowlders, and small amounts of drift in other forms. The amount of drift per square mile on the four-fifths to the south is probably less than the amount on the one-fifth to the north."

Both here and in Kansas the outermost drift appears to the writer of this review to be of less antiquity than is supposed by Salisbury. From the amount of subaerial erosion which he thinks to have been effected by the rains, rills, and large streams, since the deposition of this drift, he concludes that it is far more ancient, as fifteen or twenty times older, than the terminal moraines and their inclosed drift sheet, which belong to the Wisconsin stage of the Glacial period. Although the outer drift is demonstrably the older, its age seems to me to be very likely no greater than four or five times the age of the Wisconsin drift. The decayed condition of the rock fragments in the outer old drift may be due to erosion from surfaces of pre-glacially decayed bedrocks; and the inequalities of distribution of that drift may be of similar character with the very irregular accumulation of the later drift on areas of drumlins. Originally patchy drift accumulation outside the boundary of the later drift in New Jersey appears more probable than isolation of the drift deposits by subsequent erosion. W. U.

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PERSONAL AND SCIENTIFIC NEWS.

MR. HORACE V. WINCHELL, of the Anaconda Copper company, Butte, is examining copper deposits in Mexico.

PROF. C. R. VAN HISE was elected, April 22d, president of the University of Wisconsin.

DR. A. E. ORTMAN, OF PRINCETON UNIVERSITY, has been appointed curator of invertebrate zoology at the Carnegie Museum of Pittsburg.

ARNOLD HAGUE, of the United States Geological Survey, was elected, April 3, a member of the American Philosophical Society, Philadelphia.

PROF. JOSEPH BARRELL, OF LEHIGH UNIVERSITY, has been appointed assistant professor of structural geology in Yale University at New Haven.

DEPOSITS OF TIN have been reported from the valley of Tuttle creek, Alaska. This stream enters the Arctic ocean a little north of Behring strait.

PROFESSOR A. W. GRABAU delivered a public illustrated lecture in Boston before the Home and Field club. His subject was "Fossils, what they are and what they teach."

GEOLOGICAL SURVEY OF WASHINGTON. Governor McBride vetoed the appropriation for this survey made by the state legislature, thus causing its suspension for at least two years.

THE AMERICAN PHILOSOPHICAL SOCIETY has appointed a committee to prepare a plan for the appropriate celebration of the bicentennial of the birth of Benjamin Franklin, in January, 1906.

RECENT DISCOVERIES OF GOLD on the Tanana river and its tributary creeks in Alaska, are said to promise that this district will equal or exceed the Klondike district in production of gold in the near future.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting on March 11th the following program was presented: "Coal bearing series of the Yukon," A. J. Collier; "Soils of the wheat lands of Washington," F. C. Calkins; "Calculation of center points in the quantitative classification of igneous rocks," H. S. Washington: "Practical workings of the quantitative classification," E. B. Mathews.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting of April 2nd the following program was presented: "Correlation of the Potomac formation in Maryland and Virginia," Lester F. Ward; "Metallic sulphides from Steamboat Springs, Nevada," W. Lindgren; "Origin of bedded breccias in Northern Arkansas," C. D. Adams; "Fish remains in Georgia," E. C. Eckel.

THE TETRAHEDRAL THEORY of the outlines of the surface of the earth receives affirmative evidence in the new map from the Antarctic by the Scottish Expedition. One of the angles of the tetrahedron should appear at the south pole according to that hypothesis. The [illegible] map appears now and contains tracts of land [illegible] thus greatly in contrast with the [illegible]

ELSEWHERE [illegible] Dr. C. H. Sternberg [illegible] explorations by him in [illegible] about 100 miles north [illegible]

Pine Creek valley, he found numerous remains of elephants and bisons and came to the conclusion, from the existence of arrow points in connection with the remains, that man was cotemporary with these animals. He recommends that these swamps should be more carefully examined.

In Colorado it is a remarkable fact that the profitable mines are distributed through every geological terrane, from the Archæan granite to the Tertiary conglomerate, and mining is going on in rocks belonging to all the principal subdivisions of geological time, and amid a variety of petrographic environment which includes nearly all of the principal sedimentary and crystalline rocks. In arriving at the age of the country enclosing these lodes it has frequently been difficult to consider the sedimentary apart from the intrusive igneous rock, and it is not too much to say that there is not a mining district among the sixty-five which he has tabulated, in which igneous rocks do not occur in close association with the ore deposits.

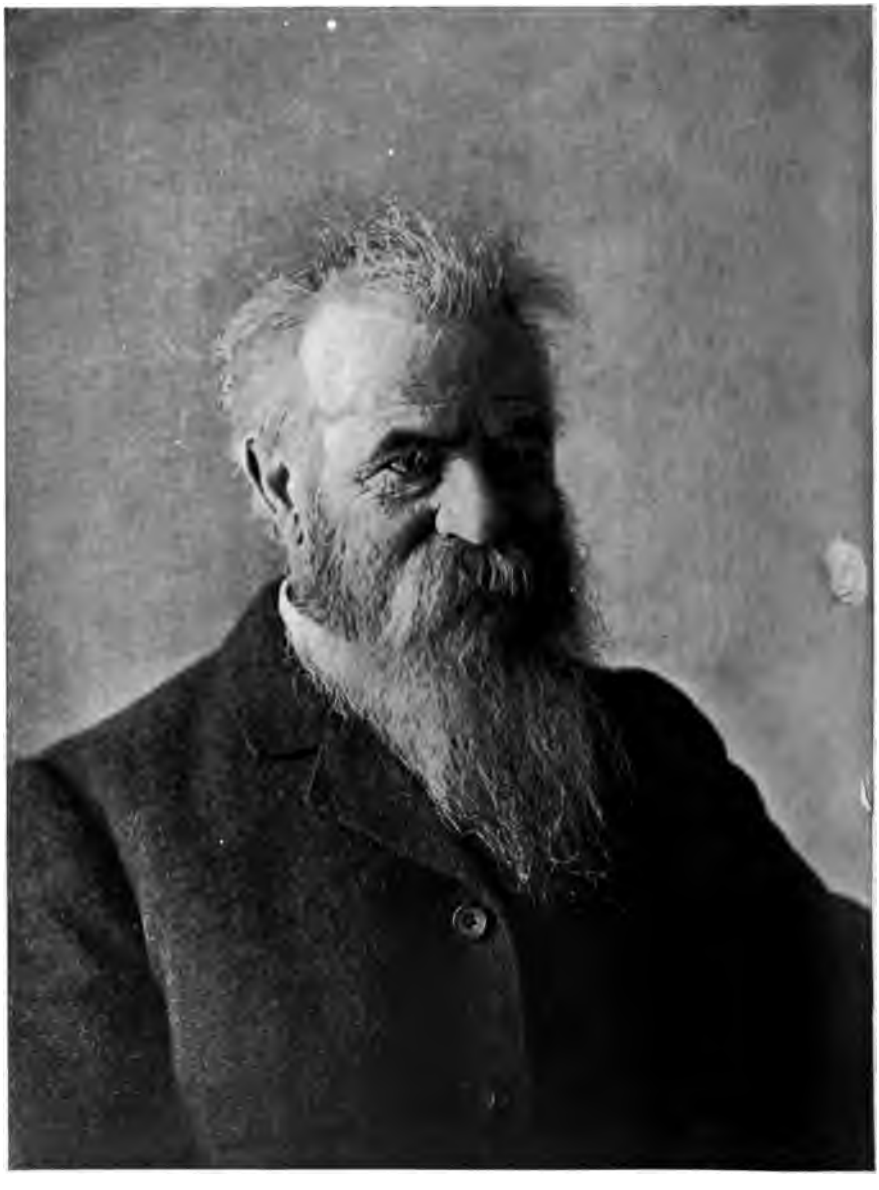
T. A. RICKARD.

THREE SCHOLARSHIPS of $200, $150 and $125 are announced for the Harvard summer geological course in Colorado under the direction of Mr. C. H. White. These scholarships are open to general application, from teachers and students of geology, whether now enrolled at Harvard University or not. Applications should be addressed to Mr. C. H. White, Rotch Building, Cambridge, Mass., and should describe the applicant's previous training in geology and his purpose in further study. Letters of recommendation should be enclosed. Action on the applications will be taken June 1. The expenses of the course, including fee for instruction, will be about $200 from Chicago and return.

MR. ELLSWORTH HUNTINGTON has lately been appointed Research Assistant by the Carnegie Institution, and will sail April 18 with professor W. M. Davis to join professor Raphael Pumpelly in Turkestan. Mr. Huntington graduated at Beloit college in 1897; he then spent four years as science teacher in Euphrates college, Harput, Turkey, and while there made an adventurous journey thro' the canyons of the Euphrates, for which he has lately received the Gill memorial from the Royal Geographical Society of London. For the past two years he has been attending the Graduate School of Harvard university, and last summer he was one of professor Davis' party in Utah and Arizona.

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JOHN WESLEY POWELL.

By GEO. P. MERRILL, Washington.

PORTRAIT—PLATE XIX.

Major J. W. Powell, director of the Bureau of American Ethnology and for thirteen years director of the U. S. Geological Survey, died at his summer home at Haven, Maine, September 23, 1902.

Mr. Powell was born of English parentage in Mount Morris, N. Y., March 24, 1834, his father being a Methodist clergyman. The requirements of his father's profession necessitated frequent changes of home, the family moving to Jackson, Ohio, when the subject of this sketch was about seven years of age. When he was twelve years of age the family moved to Walworth county, Wisconsin, and again, when seventeen, to Illinois, in which state he remained until the breaking out of the civil war.

From early childhood Powell manifested deep interest in all natural phenomena. Original and self-reliant to a remarkable degree, he early undertook collecting and exploring trips quite unusual for a youth of his age, and studied botany, zoölogy, and geology wholly without the aid of a teacher. For a time in the winter of 1850 he attended school at Janesville, but much of his education seems to have been picked up at odd moments. During his residence in Wisconsin he taught school on Jefferson prairie for fourteen dollars a month, studying hard in the meantime and giving frequent lectures on geography. After their removal to Illinois his father became one of the trustees of the college at Wheaton, and young Powell attended the institution at intervals, teaching in the

meantime at Decatur and Clinton. He also took partial courses at Jacksonville and Oberlin colleges, but was never graduated.

He traversed various portions of Wisconsin, Illinois, Iowa, and the Iron Mountain regions of Missouri, making collections of shells, minerals, and general natural history objects, which led to his election in 1859 to the secretaryship of the Illinois Natural History Society. It is said that, in 1856 when but twenty-two years of age, he descended the Mississippi alone in a row boat from the Falls of St. Anthony to its mouth, making collections on the way. Again, in 1857, he rowed the whole length of the Ohio river from Pittsburg to its mouth, and in 1858 made a like trip down the Illinois river to its mouth and thence up the Des Moines.

With the outbreak of the civil war Powell enlisted in the 20th Illinois volunteers, and was mustered in as second lieutenant. He was for a time stationed at Cape Girardeau and as captain of battery F of the 2nd Illinois artillery took part in the battle of Shiloh, losing his right arm at Pittsburg Landing. He returned to the service as soon as his wound healed, and took part in the battles of Champion Hill and Black River Bridge. At the close of operations about Vicksburg he was obliged to submit to a second operation on his arm, but returned to his post in season to take part in the Meridan raid. Later he was made major and chief of artillery, first, of the 17th army corps and subsequently, of the department of Tennessee, taking part in the operations before Atlanta and in the battle of Franklin.

At the close of the war he accepted the position of professor of geology and curator of the museum of the Illinois Wesleyan University at Bloomington, from which institution, although not a graduate, he had previously received the degrees of A.B. and A.M. He also became connected with the Illinois Normal University and was widely known throughout the state by his lectures and addresses on scientific subjects.

In May, 1867, Powell visited the Rocky mountains of Colorado, taking with him a party of sixteen students. This was before the completion of the Pacific R. R. and when the country was still infested by Indians. The party ascended

Pike's peak and mount Lincoln. After the breaking up of the party at Denver, major Powell and his wife, who had accompanied him, visited Middle park of Colorado and continued their explorations until snow interfered.

In 1868 Powell organized a party for the purpose of a second expedition into Colorado, finally going into winter quarters on the White river. During this trip he made important studies in high altitudes, ascending Long's peak for the first time and traversing a considerable portion of the mountain system of Colorado.

In the summer of 1869 he organized an expedition for the purpose of exploring the Grand Cañon of the Colorado itself, a region up to this time almost wholly unknown and concerning which there were many vague and often wild rumors. The party, consisting of eleven men with four boats and provisions for ten months, started on its voyage on May 24 and emerged from the mouth of the Grand Cañon August 29 following, having made a journey of nearly 900 miles and one which has been described as unequaled in the annals of geographical exploration for the courage and daring displayed in its execution. The immediate geological results of this trip were very slight. Nevertheless, the prestige gained was such as to be of great benefit to Powell throughout his entire career.

Explorations of the cañon and adjacent regions were continued during 1870, 1871, and 1872, the results being published in 1875 under the caption of *Explorations of the Colorado River of the West and its Tributaries*, in form of a quarto volume of nearly 300 pages. It was in the second part of the report, relating to the physical features of the valley of the Colorado, that Powell called attention to the fact that the Uintah cañons were gorges of corrosion and due to the action of rivers upon rocks which were undergoing gradual elevation. As he expressed it, the river preserved its level, but the mountains were lifted up, as the saw revolves on a fixed pivot, while the log which it cuts is moved along, the river being the saw which cuts the mountain in two. This, it will be remembered, was essentially the idea advanced by Hayden with reference to the cañons of the Yellowstone, Madison and Gallatin in his report on the geol-

ogy of Montana (1872, p. 85). In this same report Powell first made use of the expressions antecedent and consequent with reference to valleys, meaning, in the first instance, that the drainage was established prior or antecedent to the corrugation of the beds by faulting and folds, and in the second case, that the valleys had directions which were dependent upon the corrugations. Valleys which were formed by streams, the present courses of which were determined by conditions not found in the rocks through which the channels are now carved, and which were in existence when the district last appeared above the sea-level, he called *superimposed* valleys. He also here used for the first time the term *base level of erosion,* which he defined as "an imaginary surface inclining slightly in all its parts toward the end of the principal streams draining the area through which the level is supposed to extend, or having the inclination of its parts varied in direction as determined by tributary streams."

He pointed out, also, that the region of the Grand Cañon was, after all, the region of less rather than greater erosion; that, had the country been favored with a rainfall equal to that of the Appalachian country, the entire area hight have been reduced to a base level which would be the level of the sea, though the evidences of such erosion might be almost wholly obliterated.

In 1871, 1872, with the aid of a Government appropriation of twelve thousand dollars, the organization known as the Survey of the Rocky Mountains was established, in rivalry with those of Hayden and Wheeler. At the head of this Powell remained until the three were abolished in 1879 and the U. S. Geological Survey created, with Clarence King at its head. It was while carrying on this survey that G. K. Gilbert was detailed to study the Henry mountains in Utah, the results of which were brought out in the now classic monograph relating to the Laccolithic Mountains.

Powell's first observations on the geology of the Uintah mountains were made in 1869. In 1871, 1874, and 1875 he again personally visited the plateau region, the last time being accompanied by Dr. C. A. White. The results of these later years of exploration are given in the quarto monograph *On the Geology of the Eastern Portion of the Uintah Moun-*

tains, which was published in 1876. In this, as in all the work of the Powell surveys, little or no attempt was made at systematic areal geology; certain striking and well-exemplified features were selected and made the subject of special monographs. In the work above noted Powell divided the region west of the Great Plains, east of the Sierra Nevadas, and south of the North Platte, Shoshone, and Sweetwater rivers, into what he designated as geological provinces, the Park province, the Plateau province, and the Basin province. The first named he described as characterized by broad, massive ranges, sometimes distinct and sometimes coalescing so as to include the great parks. The mountains comprise high, lofty, snow-clad peaks which form perennial reservoirs for the multitude of streams discharging in part into the Colorado river and thence into the Gulf of California, and in part into the Rio Grande and thence into the gulf of Mexico. The Plateau province he described as characterized by many tables bounded by cañon and cliff escarpments and on which stand lone mountains and irregular groups of mountains and short ranges. This region drains wholly into the Colorado river. The Basin province was characterized by short north and south mountain ranges and ridges separated by desert valleys and with a drainage which is almost wholly into the interior salt lakes and sinks.

Devoting himself mainly to the Uintahs, Powell showed that they owed their present configuration to the degradation of a great upheaved block having its axis in an east and west direction. This upheaval, which he thought took place very slowly and gradually, began at the close of Mesozoic time and continued with slight intermission until late Cenozoic. The total amount of upheaval in the axial region was more than thirty thousand feet. Contemporaneous with upheaval the forces of degradation were at work, though not at the same rate of progress, along the axial line of uplift, the degradation amounting to more than twenty-five thousand feet (4¾ miles) and the mean degradation to 3½ miles, so that, over the entire area of about 2,000 square miles, some 7,100 cubic miles of material has been removed.

During 1873, 1875 and 1876 captain Clarence Dutton of the Ordnance Department of the U. S. Army, made further

studies in the plateau region with the facilities afforded by the Powell survey, the results of which appeared in his now well known report on the Geology of the High Plateaus of Utah, a quarto volume of 307 pages, with an atlas.

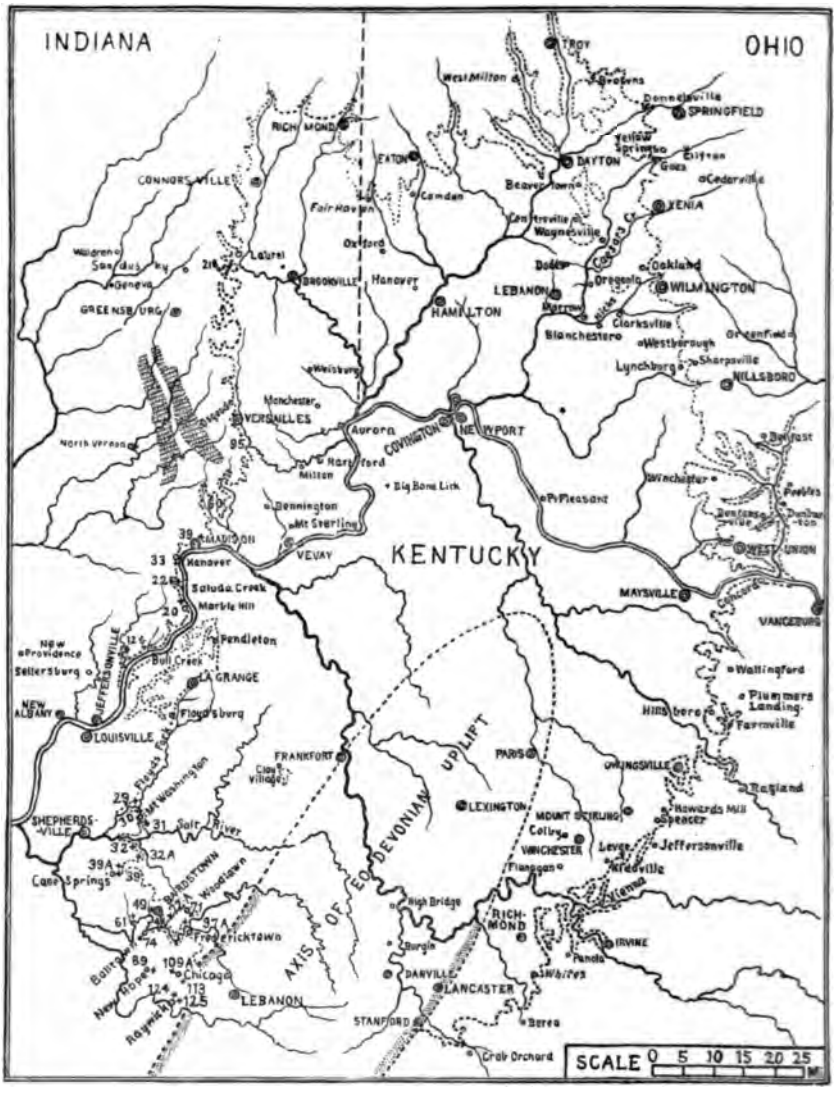
Powell's active work as a geologist practically ceased with the report on the Uintah mountains, above noted, although in 1874, 1875 he gave much attention to the irregularities of the land laws in the west and published in 1887 a work on the lands of the arid region.

In March, 1881, he assumed the directorship of the U. S. Geological Survey on the resignation of Clarence King. From this time until his voluntary retirement from the survey in 1895, during which time he was also the head of the Bureau of American Ethnology, his duties were necessarily almost wholly of an executive character. Under his administration the survey grew from a small organization, the headquarters of which were in the northeast corner of the present U. S. National Museum building, and with annual appropriations amounting to $156,000, to one which, at the time of his relinquishment, was receiving appropriations of nearly half a million dollars annually.

It is upon his success as an administrator rather than as a geologist that Powell's fame must clearly rest, although the impetus which his work on the Grand Cañon and Uintah Mountain region gave to the study of physiographic geology can never be lost sight of. Powell was eminently a magnetic man. More than this, he believed thoroughly in giving every man an opportunity to show what there was in him. Always accessible, even to the least of his employes, always interested in their welfare, he was, nevertheless, in touch with the leading thinkers and workers in all branches of science. After his retirement from the survey (in 1894), a matter which was brought about in part, at least, through failing health, his amputated arm being a source of great periodic pain, he limited himself mainly to abstruse psychological problems and the directorship of the American Bureau of Ethnology.

The immediate cause of his death, it should be stated, was a cerebral hemorrhage.

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Although himself not a college graduate, Powell received in 1886 the degree of Ph.D. from Heidelberg, Germany, and and that of LL.D. from Harvard. In 1862 he married Miss Emma Deane of Detroit. His widow and one daughter survive him.

THE RICHMOND GROUP ALONG THE WESTERN SIDE OF THE CINCINNATI ANTICLINE IN INDIANA AND KENTUCKY.

By Aug. F. Foerste, Dayton, Ohio.

PLATES XX-XXII.

CONTENTS.

A. The subdivisions of the Cincinnati series..... 333
The Mount Auburn bed..... 334
The Warren bed..... 335
The base of the Lower Richmond..... 336
The top of the Lower Richmond..... 339
The Middle Richmond..... 340
The base of the Upper Richmond 342
The top of the Upper Richmond..... 346
B. Decrease in thickness of the Richmond group..... 348
I. Indiana..... 348
The Richmond stage..... 348
The Middle and Lower Richmond..... 348
II. Kentucky..... 349
The Richmond stage..... 349
The Middle and Lower Richmond..... 350
Coral reefs in Kentucky and Indiana..... 352
The Upper Richmond..... 354
C. Conclusions 354

A. The Subdivisions of the Cincinnati Series.

In Ohio, that part of the Ordovician system which overlies the Trenton is included in the Cincinnati series. The Cincinnati series is divided into three stages of nearly equal thickness: the Richmond stage, which attains a thickness of about 235 feet along its northern line of outcrop in Indiana and Ohio; the Lorraine stage, 300 feet thick; and the Utica stage, 260 feet thick. The various subdivisions of these stages* are given in the following table, in descending order:—

* "The Geology of Cincinnati," J. M. Nickles, *Jour. Cincinnati Soc. Nat. Hist.*, 1902, No. 2. The writer is much indebted to this paper, and also to many suggestions given personally by Mr. Nickles, in the field and elsewhere. The writer accompanied Mr. Nickles on a trip during which the localities between Versailles and Marble Hill were visited.

Richmond stage.....	Saluda, Madison, or Upper Richmond bed,	60 feet.
	Middle Richmond,	115 feet.
	Lower Richmond,	60 feet.
Lorraine stage.....	Warren bed,	70 feet.
	Mount Auburn bed,	20 feet.
	Corryville bed,	60 feet.
	Bellevue bed,	20 feet.
	Fairmount bed,	80 feet.
	Mount Hope bed,	50 feet.
Utica stage*.....	Upper Utica,	60 feet.
	Middle Utica,	120 feet.
	Lower Utica,	80 feet.

The Mount Auburn Bed.

The Mount Auburn bed is characterized by the presence, in great numbers, of a large, globose form of *Platystrophia lynx*,† with a hinge-line considerably shorter than the width of the shell. This globose form may be regarded as a senile, gerontic variation of a second, equally large form having a much greater vertical range. In the second form the hinge line equals or slightly exceeds the width of the shell, thus giving the shell a more quadrate outline.‡ In Ohio, a few stray specimens of the large quadrate form are seen in the Fairmount, Bellevue, and Corryville beds; they occur most abundantly, associated with the gerontic specimens, in the Mount Auburn bed; and they are found in the Morris Hill section, three miles northwest of Oregonia, in the Warren bed, forty feet above the Mount Auburn bed. In many parts of Kentucky, especially east of the Cincinnati anticline, the quadrate form has about the same vertical range, namely from the Fairmount to the Warren beds, but it is much more abundant in the lower beds there than in Ohio. In Kentucky, therefore, the name *Platystrophia lynx bed* includes a large part of the Lorraine, while in Ohio the name is restricted to the Mount Auburn bed, which is characterized by the presence of numerous senile or gerontic specimens.

In the upper part of the Mount Auburn bed at Madison, Indiana, a species of Plectorthis occurs which resembles *Plect-*

* Paleozoic seas and barriers, ULRICH and SCHUCHERT, *Report, New York State Paleontologist*, 1901 (Published in 1902), p. 643.

† "The Morphogenesis of Platystrophia," E. R. CUMINGS, *Am. Jour. Sci.*, 1903, p 12, 26.

‡ *Ibid.*, p. 19, 24.

orthis fissicosta as figured by Meek.* The area of the ventral valve is large, forming an angle of about seventy degrees with the plane separating the valves. The convexity of the ventral valve however is much less; the shell has a flattened appearance anterior to the beak, and is often slightly depressed near the middle of the anterior margin, giving a slightly sinuous outline to this part of the shell. There is also a greater inequality in size between the plications originating at the beak and those added later, so that the earlier formed plications are more conspicuous along the anterior half of the shell. The same form occurs in the Corryville bed at Cincinnati, Ohio, where it is identified as *Plectorthis dichotoma*. *Plectorthis fissicosta* of Meek, from the Fairmount beds at Cincinnati is also identified as *Plectorthis dichotoma*, by Schuchert.† The Corryville and Mount Auburn specimens just described may be easily distinguished from the Fairmount specimens now referred to *Plectorthis dichotoma*.

The Warren bed.

The most characteristic brachiopod of the Warren bed is *Dinorthis retrorsa*: it is restricted, however, to a very short vertical range near the middle of the bed. Along the creek directly north of Lebanon, Ohio, a coarse limestone layer, four inches thick, occurs thirty-three feet above the Mount Auburn bed. The limestone layer is found at the north end of a large exposure on the west side of the creek, near the base. Three feet above this layer, *Dinorthis retrorsa* occurs associated with *Leptaena rhomboidalis*. Specimens of *Dinorthis retrorsa* were collected also eight feet above the limestone layer; the vertical range is therefore five feet.

About seven miles northeast of Lebanon, Cæsar's creek flows into the Little Miami river from the east. Almost directly opposite, Lick run enters the river from the west. Lick run has its source in a spring located on the northeast side of a rise of land, formerly known as Morris hill, about two miles west of the river. The section along Lick run was used by professor Orton to determine the thickness of his Lebanon beds, which included both the Warren and the Richmond beds. The Mount Auburn bed is not exposed here. The large, quad-

* *Pal. Ohio*, vol. i, 1873, pl. 8, fig. 6.

† Synopsis of American Fossil Brachiopoda, p. 312.

rate form of *Platystrophia lynx* is rather common in a layer of limestone occurring thirty-four feet above the level of the river. Three feet farther up, there is a coarse limestone layer, its upper surface strongly wave-marked, the trend of the ridges approximately north and south. Three and a half feet above the wave-marked layer, *Leptaena rhomboidalis* occurs. Four feet above the wave-marked layer, *Dinorthis retrorsa* is rather common, and its range extends fully six feet above this level.

Above the *Dinorthis retrorsa* layers, in the Lebanon section, there is blue clay, sixteen feet thick, soft near the base, nodular near the top. Overlying the clay is nodular clayey limestone, three and one-half feet thick, which may be regarded as forming the top of the Warren bed. The topmost layer is wave-marked in places, the trend of the ridges being approximately north and south. The nodular character of the rock and the wave-marking suggest turbulent waters during the deposition of the upper Warren beds. This was followed by a change of fauna inaugurating the Richmond age.

The base of the Lower Richmond.

Zygospira kentuckiensis has been found in Oldham and Jefferson counties in Kentucky, and at the mouth of Bull creek, in the northeastern part of Clark county in Indiana. At the last named locality it occurs at the contact of the Lorraine with the Lower Richmond. At Clarksville, Ohio it occurs in the upper part of the Lower Richmond, about four feet below the horizon of *Herbertella insculpta.*

The nodular, clayey limestone at the top of the Warren bed, in the Lebanon section is overlaid by thin, well bedded layers of clay and limestone; the total thickness is four feet; the top is formed by a four inch layer of hard limestone. Immediately above, in the blue clay and in the interbedded thin limestone layers, *Dalmanella jugosa* is common. Nine feet above the Warren bed there is a more massive layer of limestone, four to nine inches thick, containing great numbers of this fossil.

In the gulley back of the blacksmith shop, at the north end of Oregonia, a station formerly known as Freeport, *Dinorthis retrorsa* occurs seventy-eight feet above the level of the river. The base of the nodular clayey limestone occurs sixteen feet

above this level. The lower part, a foot and a half thick, is more connected; the upper part, three and a half feet thick, consists of nodular limestone masses more or less separated by clay. This forms the top of the Warren bed. Five feet above this level *Dalmanella jugosa* occurs in a very clayey limestone. A layer of hard limestone containing great numbers of this fossil is found seven feet higher up. The upper range of this fossil is not well exposed here.

Two miles south of Oregonia, on the main road from Lebanon to Wilmington, *Dinorthis retrorsa* occurs ninety-one feet above the level of the railroad, at a little stone culvert, just north of the bend where the road ascending the hill turns sharply eastward. The top of the Warren bed is twenty-one feet farther up, and five feet higher *Dalmanella jugosa* occurs in a clayey nodular limestone. It is much more abundant in the clays and thinbedded limestones immediately above, and has a range of at least fifty feet. At this locality the lowest specimens of *Strophomena rugosa* were found in the upper part of the *Dalmanella jugosa* zone.

Along its northern line of outcrop in Ohio and Indiana, the lower part of the Lower Richmond is characterized by the great abundance of *Dalmanella jugosa*. While at several localities this species appears to occur in small numbers in the upper, nodular part of the Warren bed, its increase in the lower part of the Lower Richmond is so abrupt that it is one of the most useful fossils for determining the line between the Warren and the Lower Richmond. Southward the Dalmanella jugosa zone thins out. While very abundant at Concord, Kentucky, no traces of this fossil were seen at Owingsville or near Spencer. On the western side of the Cincinnati anticline, it has not been seen south of Marble Hill in Indiana.

The most southern outcrop of *Dinorthis retrorsa* on the eastern side of the Cincinnati anticline is at Arnheim, in Brown county, thirteen miles north of the Ohio river. *Dalmanella jugosa* and *Hebertella insculpta* are common at Concord, Kentucky. *Catazyga headi* occurs ten miles south of Maysville, Kentucky.

Protarea vetusta, Streptelasma rusticum (*Str. corniculum* of the Ohio survey), *Strophomena sulcata*, and *Rhynchotrema capax* range from the lower part of the Lower Richmond to

the top of the Upper Richmond. Since they are not known to occur in the Lorraine in the area under discussion, these species are very useful for distinguishing between the Lower Richmond and the Warren beds in those parts of Indiana and Kentucky in which the Dalmanella jugosa zone is absent. Usually they are rather infrequent in the lower and middle part of the Dalmanella zone and do not become abundant until the upper part of this zone is reached.

Strophomena rugosa (*Str. planumbona* of the Ohio Survey) is another Richmond fossil which usually does not become abundant until the middle or upper part of the Dalmanella jugosa zone is reached. The radiating striæ are of medium size, and do not differ conspicuously in size either when striæ on the same valve, or when striæ belonging to opposite valves are compared. *Strophomena elongata* James, is a variety of *Strophomena rugosa*, differing only in the greatly extended hinge-line, which gives a subtrigonal, instead of the usual subquadrate outline to the shell. *Strophomena subtenta* (*Str. plicata* of the Ohio Survey) is another variety, of larger size than the typical *Str. planumbona;* the oblique wrinkles near the extremities of the hinge-line are often absent. *Strophomena elongata* and *Str. subtenta* are typically developed in the lowest part of the Middle Richmond. Forms intermediate between these varieties and *Str. planumbona* occur in the upper part of the Lower Richmond. *Strophomena neglecta* has been collected by Dr. G. M. Austin in the upper ten feet of the Lower Richmond near Clarksville, Ohio. It is a larger shell than *Str. vetusta,* often attaining a width of 50 mm. The convexity of the dorsal valve is much greater, the depth amounting to 1.8 mm. in shells 42 mm. long. The striæ are much finer and closer over the larger part of the shell, and equal in coarseness those of the dorsal valve of *Str. vetusta* only along the anterior third of the shell. The chief characteristics of *Strophomena nutans* are its subnasute anterior margin and the remarkable thickening of the interior of the ventral valve around the muscular area and along the anterior margin. The radiating striæ are very fine; some, at more or less regular intervals are slightly more prominent. The typical specimens are rather small, mature specimens attaining a length of four-fifths of an inch. They oc-

cur in the middle and upper part of the Lower Richmond. At Concord in Kentucky, specimens having the same general form as *Strophomena nutans* are found at the base of the *Dalmanella jugosa* zone, eighteen feet below the lowest specimens of *Strophomena rugosa*. Many of these specimens attain a length of one inch and a width along the hinge-line of an inch and a quarter. The striæ of both valves are fine; some are more prominent, three to six intermediate striæ being less conspicuous. About six to nine of the more prominent striæ occur in a width of a quarter of an inch.

The top of the Lower Richmond.

At the bridge across Todd's Fork, northwest of Clarksville, Ohio, *Dalmanella jugosa* occurs sparingly in the clayey limestone at the base of the section. Immediately above, it becomes very common, and remains common as far as forty to forty-three feet above the level of the creek. Forty feet above the creek there is a wave-marked layer of limestone, with the ridges trending approximately northeast and southwest. Fifty feet above the creek, *Hebertella insculpta* is rather common, but is restricted to only a few feet in the vertical section. *Dalmanella jugosa* occurs sparingly up to this level, and even for five or more feet above the same.

The *Hebertella insculpta* horizon may be regarded as forming the top of the Lower Richmond. It has not yet been definitely determined that this fossil is restricted to the top of the Lower Richmond, but it is known at least to be quite constant in its appearance at this horizon in northeastern Kentucky, all of Ohio, and in Indiana as far south as Weisburg and Versailles. It may be that it occurs as far south as Madison but no specimens have been collected there.

At Versailles, in Indiana, *Rynchotrema dentatum* makes its first appearance in the Lower Richmond at a level one or two feet beneath that of *Hebertella insculpta*. At Dayton, Ohio, and at Richmond, Indiana, its range extends to the top of the Middle Richmond. While it is not known to occur in the lower part of the Lower Richmond, a very similar, if not identical form has been found in the upper part of the Warren bed half a mile southeast of Howard's mill in Montgomery county, Kentucky. It possesses three distinct plications and one indistinct plication on each side of the dorsal fold instead of

four distinct and one or two indistinct plications, as in the Richmond group. In consequence, the plications appear more angular. A single specimen of the Warren bed form was collected by Mr. J. F. Hammel at Madison, Indiana, but the exact horizon from which it was collected is unknown.

Catyzyga headi may prove to be a very valuable horizon marker. It appears to have a very restricted vertical range. At Clarksville, Ohio, it has been collected, by Dr. George M. Austin, about fifteen feet below the horizon of *Orthis insculpta.* Lower down along Todds Fork, in Warren county, it has been collected by the same observer at the same level, near the hill tops about Hicks station. At Madison, Indiana, where the *Hebertella insculpta* horizon is unknown, *Catyzyga headi* is found fifty feet above the base of the Richmond. This must be somewhere near the top of the Lower Richmond.

Dinorthis scovillei has so far not been found outside of the limits of Warren county, Ohio, although it is a well characterized species. This is probably due to its very limited vertical range. On Longstreth's creek, west of Oregonia, it occurs at about the same level as *Gaurocrinus nealli,* a short distance below the *Dendrocrinus caduceus* horizon, and a greater distance below the *Hebertella insculpta* horizon. *Dalmanella jugosa* occurs farther down the creek.

The type of *Lingula vanhornei* was found in the Lower Richmond, at Versailles, Indiana.

The Middle Richmond.

Dinorthis subquadrata, Hebertella occidentalis, Platystrophia acutilirata, and *Strophomena* vetusta (*Str. filitexta* of the Ohio survey) make their first appearance in the Middle Richmond and are therefore very serviceable in distinguishing the middle Richmond from the Lower Richmond in the areas in which *Hebertella insculpta* is absent. *Dinorthis subquadrata, Hebertella occidentalis,* and *Platystrophia acutilirata* occur also in the fossiliferous horizons of the Upper Richmond. Typical specimens of *Hebertella occidentalis* occur along Elkhorn creek near Richmond, Indiana, twenty-seven feet below the Clinton. Forms with only a moderate depression along the middle of the dorsal valve occur in the upper beds as far as the base of the Richmond.

Platystrophia acutilirata is a descendant of *Platystrophia laticosta*. The typical specimens of *Platystrophia laticosta* begin their appearance in the Bellevue bed, and thence continue through the remainder of the Lorraine stage into the Lower Richmond. In the Lower Richmond a part of the specimens show an increase in the number of lateral plications and a prolongation of the postero-lateral angles, features which find their most pronounced expression in *Platystrophia acutilirata*. *Platystrophia cypha* from the Lower Richmond, is evidently one of the transitional forms in which the increase in the number of lateral plications and the prolongation of the postero-lateral angles has been accompanied by a reduction in the number of plications on the median fold and in the sinus.

Strophomena planumbona occurs in the middle part of the Lower Richmond. *Strophomena subtenta* is found in the lower part of the Middle Richmond. Specimens intermediate between *Strophomena planumbona* and *Strophomena subtenta* are found in the upper part of the Lower Richmond In typical specimens of *Strophomena subtenta* the thickening of the border around the anterior and lateral margins of the interior of the shell is comparatively small, the muscular cavity is less prominently bordered, and the shell attains a larger size. The posterior half of the dorsal valve is distinctively flattened and usually slightly concave anterior to the beak. The striations of the ventral valve are about equal in size to those of the dorsal valve. *Strophomena vetusta* differs from *Strophomena subtenta* in the much smaller and more even convexity of the dorsal valve, and in the very slight flattening of this valve near the beak. The radiating striations of the ventral valve are conspicuously finer than those of the dorsal valve. Moreover, the radiating striations of the ventral valve are crossed by fine concentric striations and wrinkles which are usually readily seen, especially on the posterior half of the shell, and are very characteristic of this species. As a rule, the cardinal area of the ventral valve is much higher at the beak in *Strophomena vetusta* than in *Strophomena subtenta*. I am under great obligations to professor Stuart Weller for the opportunity of examining the type specimens of *Strophomena vetusta* in Chicago University.

They were found at Blanchester, Ohio, in the Middle Richmond. The wrinkling of the shell along the hinge-line is scarcely a specific character, and may be absent. *Strophomena vetusta* makes its first appearance in the lower part of the Middle Richmond and is usually abundant in the middle and upper part.

Strophomena approximata is a subtrigonal form of *Str. vetusta*. The type specimens were found in Dearborn county, Indiana, in the Middle Richmond.

All of the exposures in the immediate vicinity of Richmond, Indiana, belong to the Middle Richmond. The base of the Middle Richmond is not seen. *Strophomena subtenta* occurs only at the very base of the exposures, while *Strophomena vetusta* occurs at all levels. At the top of the exposures *Strophomena sulcata* is rather frequent.

The base of the Upper Richmond.

Along the northern line of outcrop, in Ohio and Indiana, the richly fossiliferous clays and limestones of the Middle Richmond are followed by a considerable thickness of clays in which fossils are much less abundant or even absent. These upper clays are referred to the Upper Richmond. Farther south, in the vicinity of Laurel, Indiana, the equivalent beds consist of a nearly unfossiliferous clay rock, forming steep walls at the base of several waterfalls but disintegrating readily under the influence of weathering. At Madison, the equivalent beds consist of an earthy, siliceous limestone which is harder than the clay rock at Laurel and is well bedded so that at one time it was quarried. Its appearance, however, has proved to be deceptive, and this rock is now known to be strongly affected by weathering. The main body of this rock at Madison does not contain fossils and elsewhere it usually contains so few fossils that its geological position long remained unknown. Upon lithological grounds it has been referred in former times to the Silurian, but an unmistakable Ordovician fauna is now known from the body of this usually nearly unfossiliferous section, and an abundant Ordovician fauna overlies it at Madison.

The separation of the Upper Richmond from the Middle Richmond must usually be effected by lithological means. The Middle Richmond consists of a series of richly fos-

siliferous limestones interbedded with richly fossiliferous clays. The Upper Richmond consists of much less fossiliferous material, varying geographically from soft clay to clay rock and to massive beds of argillaceous limestone, fairly homogeneous throughout the greater part of the vertical section.

In the vicinity of Madison, Indiana, the more massive, banded, argillaceous limestone is thirty-two feet thick. At its base and also higher up in the series, some of the layers show ripple marks and sun cracks. Beneath this, the rock is softer, more clayey, disintegrates more readily, often forming a clayey section, fifteen to seventeen feet thick. The base of the clayey section is formed by a layer, one or two feet thick, which evidently at one time formed a thin coral reef. Massive specimens of *Columnaria alveolata* (*Favistella stellata* of the Ohio and Indiana surveys), and *Columnaria halli* (*C. alveolata* of most authors of former days) are very common. Many of the specimens form masses six inches thick and twelve inches broad. A few are a foot and a half thick and nearly three feet broad. Specimens of *Calopoecia cribriformis* are rather scarce. Occasional specimens of *Tetradium minus* are found. The last named fossil occurs also in layers six feet, and seven and a half feet above the coral bed, and in a layer two feet below this bed.

This coral bed may be traced southwestward as far as Hanover, and northeastward as far as the northern part of Jefferson county. Stray specimens of *Columnaria alveolata* have been found at the same horizon as far south as the D. P. Monroe locality, one mile northwest of the Pinckney Swan locality, and as far north as Versailles.

At Versailles, *Tetradium minus* occurs at all levels in the thirteen feet which overlie the layer containing *Columnaria alveolata.* It is quite abundant in about nine feet of the section. The base of the *Tetradium* bed at Versailles is, therefore, approximately at about the same level as the coral bed at Madison. This is believed to be the case also at Laurel, where no *Columnaria* has been found, but where a *Tetradium minus* layer, three to four feet thick, occurs at a corresponding level. At Richmond, Indiana, small specimens of *Columnaria alveolata* and *Columnaria halli*, not exceeding two inches in diameter, occur associated with *Beatricea undulata* on Elkhorn creek fif-

teen feet below the Clinton. In the valley of Whitewater river John Misner found two specimens of *C. alveolata* near the base of the Middle Richmond, and two equally large specimens of *Calopoccia cribriformis* were found, one near the base and the other near the top of the Middle Richmond.

Wherever, in Indiana, the horizon of the coral reef exposed at Madison can be determined, or wherever *Tetradium minus* forms a well marked zone at practically the same horizon, the base of these beds is considered the paleontological base of the Upper Richmond.

A great coral reef, made up of numerous specimens of *Columnaria alveolata, Columnaria halli,* and *Calopoecia cribriformis* is found also in central Kentucky, in Nelson, Marion, and Washington counties. It occurs at the base of the Richmond section as exposed in that part of the state. This coral bed in central Kentucky probably was not synchronous with the coral bed in southern Indiana. Although the lower and middle beds of the Richmond stage thin out rapidly southward, so many Middle Richmond fossils occur in the lower part of the Richmond section in central Kentucky, just above the coral bed, that it seems probable that the coral reef of central Kentucky is of earlier date than the coral reef at the base of the Upper Richmond in southern Indiana.

While the base of the Upper Richmond at many localities in southern Indiana is characterized by the presence of numerous specimens of *Columnaria alveolata, Columnaria halli, Calopoccia cribriformis,* and *Tetradium minus,* none of these fossils are confined to this horizon.*

Columnaria alveolata occurs in the Black River limestone of Ontario, and in the Trenton formation of Manitoba and of the district of Mackenzie. It is found at the top of the Lorraine, associated with *Dinorthis retrorsa,* at Clifton, Tennessee. Small specimens, three inches in diameter, occur above *Hebertella insculpta* at Concord, Ky. Small specimens are found also in the lower half of the Middle Richmond, on East Fork of Todds Fork, Ohio, and fifteen feet below the base of the Clin-

* "A revision of genera and species of Canadian paleozoic corals," L. M. LAMBE, 1901, pp. 43, 90, 93, 98, 100, 110.
The Cincinnati Group in Western Tennessee, *Journal of Geology,* 1903, p. 37.
"Corals from the Lower Silurian of Minnesota," *Geology of Minn.*, vol. iii, part 1, WINCHELL and SCHUCHERT, pp. 85, 93, 94.

ton in the valley of Elkhorn creek, near Richmond, Indiana. Two large specimens were collected by John Misener near the base of the Middle Richmond, at Richmond, Indiana.

Columnaria halli is typical of the Birdseye and Black river formations in Quebec and Ontario. It occurs in the Black River group of New York. It is found in the Trenton of Minnesota, Wisconsin, Illinois, Kentucky, and central Tennessee. It is abundant in the Upper Lorraine at various localities in Bullitt, Nelson, and Marion counties in central Kentucky, associated with *Beatricea undulata.* One specimen referred to this species was collected above the *Hebertella insculpta* zone at Concord, Kentucky. It occurs about eighteen feet below the top of the Lower Richmond near Clarksville, Ohio, and also twenty feet above the base of the Middle Richmond in Roaring run, in Warren county. Along Elkhorn creek near Richmond, Indiana, small specimens occur fifteen feet below the base of the Clinton.

Calopoecia cribriformis is probably identical with *Calopoecia canadensis.* It occurs in the Birdseye near Ottawa; in the Black river at the north end of lake Huron, in the province of Quebec, and on Anticosti; in the Galena-Trenton in Manitoba and in the district of Saskatchewan; and in the socalled Hudson river of the northern end of lake Huron, in the province of Quebec, and on Anticosti. It occurs in beds which may belong to the top of the Lorraine at the Lang Smith locality, a mile and a half southeast of Chicago, in Kentucky, and at the home of George Raley, 3 miles southeast of Lebanon, Kentucky. It has been found by Dr. G. M. Austin at the top of the Lower Richmond, in Cowans creek near Clarksville, Ohio. Two specimens were collected by John Misener at Richmond, Indiana, one near the top and the other near the bottom of the Middle Richmond.

Tetradium minus is probably identical with *Tetradium fibratum.* These forms range from the Birdseye and Black River formations in Canada, to the Galena-Trenton in Manitoba, and to the Trenton in Kentucky and Tennessee. *Tetradium minus* occurs at the top of the Lorraine near the mouth of Bull creek, in Clark county, Indiana. In southern Indiana, Ohio, and Kentucky, it is common at the top of the Upper Richmond.

The chief thing which is characteristic of the occurrence of these corals at the base of the Upper Richmond in southern Indiana is their great abundance and large size at this particular horizon, indicating the presence of a coral reef. This coral reef is occasionally followed at intervals of several feet by other beds in which the same species of corals occur, but in these beds the corals are less numerous and usually much smaller. Elsewhere in Indiana and Ohio these corals occur only as occasional specimens not forming reefs.

Along Elkhorn creek, four miles south of Richmond, the highest exposures containing *Strophomena vetusta, Dinorthis subquadrata, Rhynchotrema dentata,* and *Strophomena sulcata* occur between fifty and sixty feet below the Clinton. The upper beds of the Richmond are more richly fossiliferous along Elkhorn creek than at any other locality in Indiana and Ohio, so far examined.

The top of the Upper Richmond.

At most localities almost the entire Upper Richmond section is unfossiliferous. The coral bed and the layers immediately above often contain a few fossils. At Madison, a whitish band of calcareous rock six feet above the coral bed contains *Cyrtolites ornatus, Bellerophon mohri, Lophospira bowdeni, Hormotoma gracilis, Ischyrodonta miseneri,* and a small variety of *Platystrophia** three quarters of an inch in width, the hinge line scarcely exceeding the general width of the shell. In the sandy layers immediately above, *Rhynchotrema capax, Strophomena sulcata, Hebertella sinuata,* and large, branching, nodular specimens of *Heterospongia aspera* are found. In the southern half of Ripley county, in Indiana, the middle part of the Upper Richmond section contains a considerable bryozoan fauna, although the number of species is apparently small. *Hebertella sinuata* and *Byssonychia radiata* are fairly common. Near Versailles the upper part of the Upper Richmond consists of sandy clay containing in addition to numerous specimens of bryozoa, also *Streptelasma rusticum, Protarea vetusta, Hebertella occidentalis, Strophomena sulcata,* and the small *Platystrophia* with a short hinge line, which occurs also lower in the section. Along Elkhorn creek, four miles south of Rich-

* "The Morphogenesis of Platystrophia," E. R. CUMINGS, *Am. Jour. Sci.*, 1903, p. 25.

mond, Indiana, the Upper Richmond is richly fossiliferous. *Bucania crassa* occurs associated in the various species of *Ischyrodonta,* seven feet below the Clinton. *Helicotoma marginata* is found associated with *Beatricea undulata* fifteen feet beneath the Clinton. It is evident that, notwithstanding the general scarcity of fossils at most exposures of the Upper Richmond, continued search will reveal a considerable fauna. Most of the forms so far identified seem to occur also in the Middle Richmond, but when the bryozoans are studied it is probable that a number of species will be found restricted to this upper subdivision of the Richmond stage.

At Madison, Indiana, fossils are found in the thin clayey partings between the upper layers of the massive banded argillaceous limestone. Immediately above are several feet of fossiliferous clay and fine grained, dense, bluish limestone. These contain, in addition to fossils found also in the Richmond beds beneath, a few fossils which are apparently typical of this horizon. Among these are *Cyrtocerina madisonensis, Lophospira hammelli,* and a species which was described as *Holopea hubbardi,* but which probably belongs to some undescribed genus. *Labechia ohioensis, Labechia montifera, Tetradium minus,* and various species of ostracoda are common at some localities, but are found also at lower horizons elsewhere. In the reports of the Indiana survey, the beds at the top of the Ordovician section at Madison are referred to as the *Murchisonia hammelli* beds,* or as the gasteropod layer. Since the most varied fauna so far obtained from this horizon was collected in West Madison along the brow of Hitz hill, on the western side of the Madison branch of the Panhandle railroad, the bed may also be called the *Hitz bed.* The most southern exposure of this bed so far seen is located about ten miles southwest of LaGrange, near Floydsburg, Kentucky, on the Alexander Sinclair farm. The most northern locality known is found two miles north of the southern boundary of Ripley county, four miles west of Cross Plains, Indiana. The distance between the extreme points named is nearly fifty miles.

* * * *

* Twenty-first Report, *Indiana Survey,* 1897, p. 222.

B. Decrease in thickness of the Richmond group.

I. *Indiana.*

The Richmond stage.

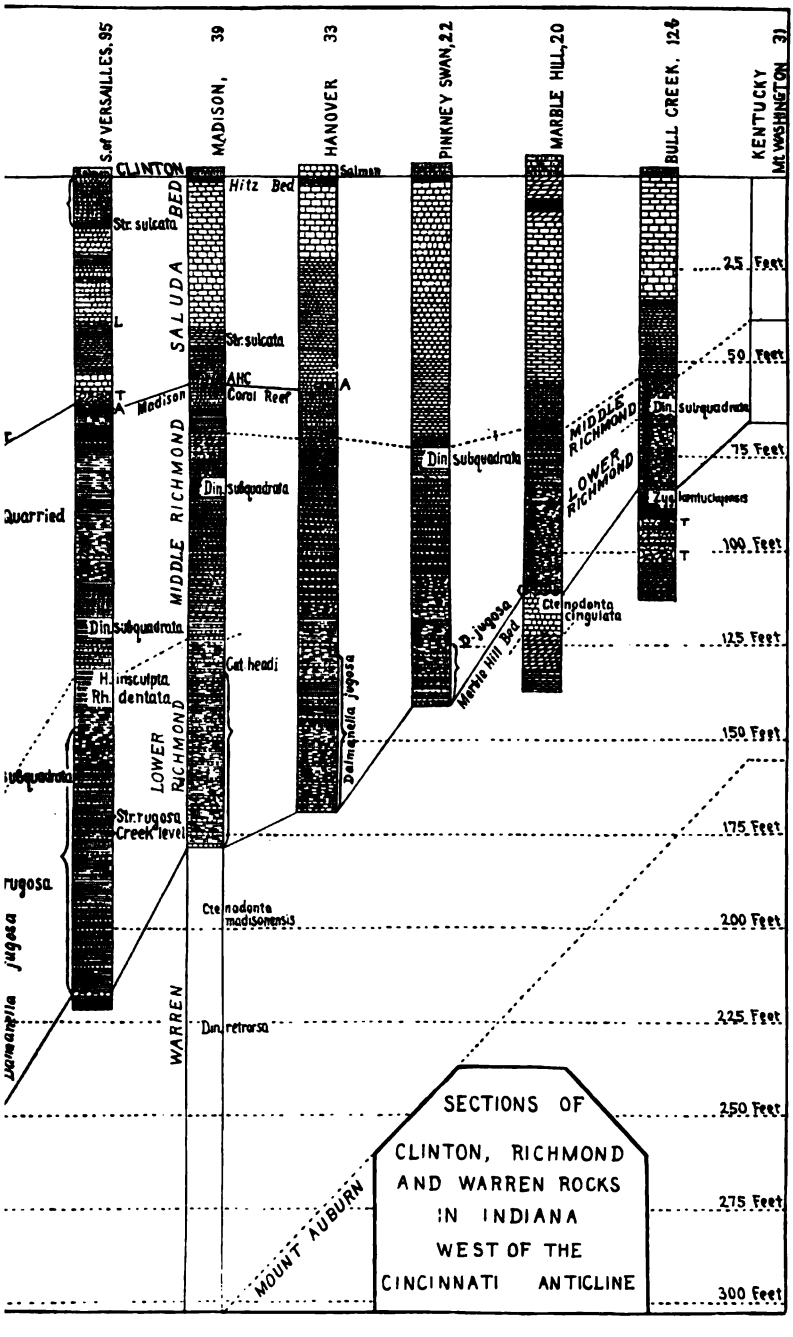
At Fort Recovery,* in the southwestern part of Mercer county, Ohio, a bed of fossiliferous limestone was struck in a gas well, at a level of 270 feet beneath the Clinton. The fossiliferous limestone continues for a depth of thirty feet. The rock is almost entirely made up of *Dalmanella jugosa.* The thickness of the Richmond stage at Fort Recovery is therefore about 300 feet. From this point southward, as far as Raywick, in the western part of Marion county, Kentucky, a distance of 200 miles, the Richmond stage becomes constantly thinner.

Between Fort Recovery, Ohio, and the Brookville-Laurel section, in Indiana, a distance of seventy miles, the thickness of the Richmond diminishes from 300 to 250 feet, an average diminution of .7 foot per mile. Between Brookville (250 feet) and Versailles (217 feet), a distance of thirty miles, the average diminution in thickness is 1.1 feet per mile. Between Versailles (217 feet) and Madison (178 feet), a distance of twenty-five miles, the average diminution is 1.6 feet per mile. Between Madison (178 feet) and Hanover (169 feet), a distance of five miles, the average diminution is about 1.8 feet per mile. Between Hanover (169 feet) and the Pickney Swan locality on Saluda creek (140 feet), a distance of five miles, the average diminution is about 5.8 feet per mile. Between Saluda creek (140 feet) and Marble Hill (111 feet), a distance of 3.5 miles, the average diminution is 8.3 feet per mile. Between Marble Hill (111 feet) and the mouth of Bull creek (83 feet), a distance of eleven miles, the average diminution of the Richmond stage is 2.5 feet per mile.

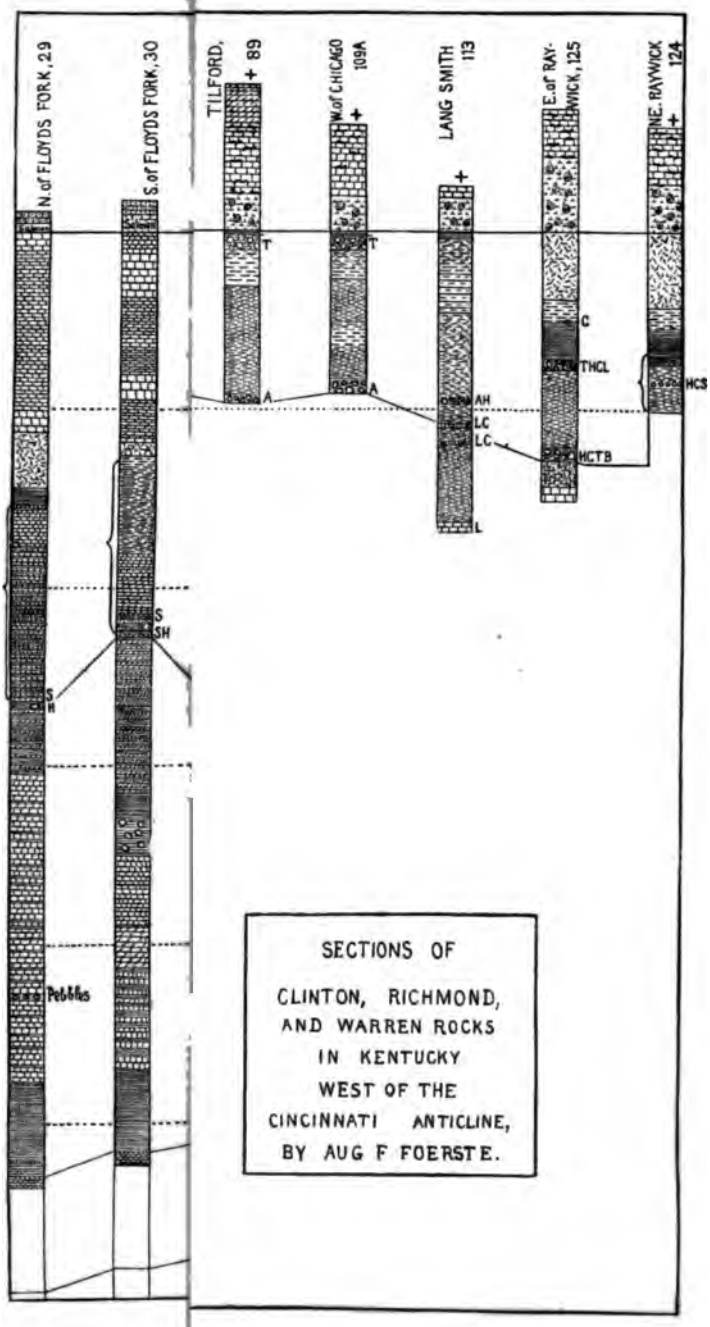
The Middle and Lower Richmond.

As far south as Hanover, Indiana, *Dalmanella jugosa* is very abundant at the base of the Richmond stage, its range extending through the greater part of the Lower Richmond. At the Pinckney Swan locality on Saluda creek, it is abundant only in a few feet of rock at the base of the Richmond section. At Marble Hill, a few specimens were found in the few inches of sandy limestone at the very base of the Richmond

* *Geology of Ohio*, vol. vi, 1888, p. 263.


S.of VERSAILLES, 35
MADISON, 39
HANOVER 33
PINKNEY SWAN, 22
MARBLE HILL, 20
BULL CREEK, 12A
KENTUCKY Mt. WASHINGTON 31
CLINTON
Hitz Bed
Str. sulcata BED
SALUDA
Str. sulcata
AHC Coral Reef
Madison
MIDDLE RICHMOND
Din. subquadrata
Cat headi
H. insculpta
Rh. dentata
LOWER RICHMOND
Str. rugosa
Creek level
Ctenodonta madisonensis
WARREN
Din. retrorsa
Salmon
Dalmanella jugosa
Din. subquadrata
D. jugosa
Marble Hill Bed
Ctenodonta cingulata
MIDDLE RICHMOND
LOWER RICHMOND
Din. subquadrata
Din. kentuckyensis
25 Feet
50 Feet
75 Feet
100 Feet
125 Feet
150 Feet
175 Feet
200 Feet
225 Feet
250 Feet
275 Feet
300 Feet
MOUNT AUBURN
SECTIONS OF CLINTON, RICHMOND AND WARREN ROCKS IN INDIANA WEST OF THE CINCINNATI ANTICLINE

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section. Two feet above the base, *Strophomena rugosa* and *Streptelasma rusticum* are found. At the mouth of Bull creek, *Dalmanella jugosa* was not observed. Southward, as far as Raywick, in Kentucky, it is apparently absent, or at least does not form a conspicuous part of the fauna at the base of the Richmond section.

The diminution in the vertical range of *Dalmanella jugosa,* from Hanover southward, is accompanied by a diminution in the thickness of both the Middle and Lower Richmond. In the following measurements the top of the richly fossiliferous part of the Middle Richmond has been chosen as the most easily recognized horizon near the top of the Middle Richmond in the southern part of the area under discussion. The thickness of the section included between the base of the Lower Richmond and the top of the richly fossiliferous beds near the top of the Middle Richmond at Madison is 110 feet; at Hanover, 100 feet; at the Pinckney Swan locality on Saluda creek, 68 feet; at Marble Hill, 44 feet; and at the mouth of Bull creek, 30 feet.

At the mouth of Bull creek, the Lower Richmond is only twenty feet thick. The fossils are most numerous in the lower eleven feet, consisting of clay and a few thin beds of interbedded limestone. The top of the Lower Richmond is formed by a wave-marked layer of limestone. Above this are ten feet of light colored clay and whitish limestone, containing *Dinorthis subquadrata,* which form the richly fossiliferous part of the Middle Richmond. Above this somewhere should be the horizon containing massive corals. A stray specimen of *Columnaria alveolata* in a sandy matrix may have come from this horizon. A single specimen of *Columnaria halli* was found in the white rubble limestone forming the Middle Richmond.

* * * *

II. *Kentucky.*

The Richmond.

Between the mouth of Bull creek, in Indiana, and the crossing of the Louisville-Bardstown pike over Floyds Fork (locality 29), in Kentucky, a distance of 25 miles, the Richmond stage diminishes from 83 feet to about 66 feet; according to this, the average rate of diminution of the Richmond stage is about .7 foot per mile. Three miles south of Floyds Fork,

along the creek south of Mount Washington, the thickness of the Richmond is apparently the same as at Floyds Fork, namely about 69 feet. However, between Mount Washington (69 feet) and the William McGrudor locality (32 feet), north of Cane spring, in the southeastern part of Bullitt county, a distance of 8 miles, the average rate of diminution is about 4.6 feet per mile. The thinnest section of the Richmond, so far discovered in Kentucky, is located along the road leading southwest from Balltown. Here the Richmond is only 22 feet thick, indicating an average diminution in thickness, in the 13 miles south of the McGrudor locality, of about .8 foot per mile.

The Middle and Lower Richmond.

The thickness of the richly fossiliferous clays and thin limestones, at the base of the Richmond stage, appears to be about the same at the crossing of the Louisville-Bardstown pike over Floyds Fork, and south of Mount Washington, as at the mouth of Bull creek, namely, between twenty-five and thirty feet. This suggests that the lower, richly fossiliferous part of the Richmond section at these localities includes both Lower and Middle Richmond strata. No attempt has been made as yet to distinguish between them. *Strophomena rugosa* occurs in the lower part of the Richmond section at Floyds Fork. *Hebertella occidentalis* has been found at the top of the richly fossiliferous section at Mount Washington.

Within a distance of four or five miles southwest of Mount Washington, the very fossiliferous part at the base of the Richmond is reduced to about fifteen feet, and about eight miles south of Mount Washington, at the William McGrudor locality, in the southeastern part of Bullitt county, its thickness is only five or six feet. Farther south, in Nelson and Marion counties, the richly fossiliferous part at the base of the Richmond varies between six and eleven feet.

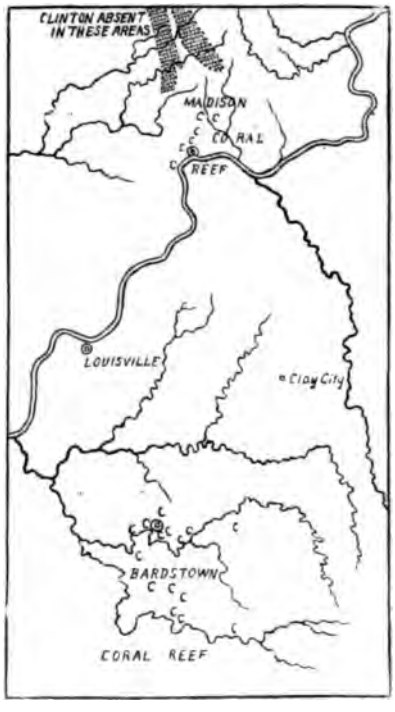
It is possible that the sudden decrease in thickness of the richly fossiliferous part of the Richmond stage between Mount Washington and the William McGrudor locality is accompanied by the disappearance of the Lower Richmond. The evidence is not conclusive. Most of the fossils found in this richly fossiliferous part of the section at the William McGrudor locality, and at the numerous localities in Nel-

son and Marion counties, belong to species common to both the Lower and the Middle Richmond. Among these are *Hebertella sinuata, Strophomena sulcata, Rafinesquina alternata, Rhynchotrema capax, Zygospira modesta, Byssonychia radiata, Lophospira tropidophora, Streptelasma rusticum, Protarea vetusta, Tetradium minus,* and various varieties of *Platystrophia.* Several species, however, are not known to have occurred earlier than during the Middle Richmond. *Dinorthis subquadrata* was found in the richly fossiliferous part of the Richmond at Bardstown. A typical specimen of *Platystrophia acutilirata* was found at Bardstown, and several, with almost equally prolonged hinge-lines, at the William McGregor locality. *Strophomena vetusta* occurs at Bardstown, Raywick, and at the McGrudor locality.

In central Kentucky, *Beatricea undulata, Beatricea nodulosa,* and *Heterospongia subramosa* appear to be more characteristic of the upper Lorraine than of any other horizon. However, at Withrows Run, west of Bardstown, both species of Beatricea have been found, associated with *Palaeophyllum divaricans and Protarea vetusta,* a short distance above the great coral bed; and, at Raywick, a large robust specimen of *Beatricea undulata* and several specimens of *Heterospongia subramosa* were collected at about the same level. Southwest of Mount Washington, along Whittakers creek, a depauperate specimen of *Beatricea undulata,* three-fourths of an inch in diameter, and *Heterospongia subramosa* occur at the base of the Richmond section, associated with *Streptelasma rusticum. Beatricea nodulosa* was collected by A. C. Benedict in the Richmond near Connorsville, Indiana. The exact horizon of the Connorsville specimen is unknown. *Beatricea undulata* occurs at Richmond, on Elkhorn creek, fifteen feet below the Clinton in the Upper Richmond. It is associated with specimens of *Beatricea* which have a smooth cylindrical form; not fluted longitudinally as in *B. undulata,* nor with distant irregular elevations as in *B. nodulosa.* Similar smooth cylindrical specimens occur east of Raywick, in Kentucky, in the great coral bed forty-one feet below the cherty beds forming the upper half of the Clinton. Another specimen was found along the road northwest of Fredericktown, Kentucky, apparently having dropped from some point below the great coral bed. At Rich-

mond the smooth cylindrical form is connected with undoubted *Beatricea undulata* by intermediate forms. To avoid definitely referring these forms to typical *B. undulata* they may be known as *Beatricea cylindrica.* On the island of Anticosti both species of Beatricea have a much more extended range, apparently from the Trenton to near the top of the Ordovician.

Coral reefs in Kentucky and Indiana.



In Nelson, Marion and Washington counties, Kentucky, an assemblage of massive corals occurs which is identical with the corals found in the coral reef at Madison, Indiana. *Columnaria alveolata* and *Columnaria halli* are common, and *Calopoecia cribriformis* occurs in considerable numbers at some localities although the specimens rarely equal a foot in diameter. To the northern coral reef the name *Madison coral reef* is here given, while the one in central Kentucky is called the *Bardstown coral reef.* Owing to similiarity in appearance the temptation is very great to consider the two coral reefs as of practically the same age. This temptation is strengthened

by the fact that the greater part of the overlying Richmond section in central Kentucky is practically unfossiliferous, and that a part of this section strongly resembles the banded, massive, argillaceous limestone forming the chief part of the Upper Richmond in southern Indiana. The occurrence immediately above the Bardstown coral bed, of fossils known to occur commonly in the Middle Richmond, does not vitiate such a conclusion since the fossils so far identified from the beds immediately above the Upper Richmond or Madison coral reef in southern Indiana are such series as also occur in greater numbers in the Middle Richmond.

However a comparison of the various Richmond sections along the western side of the Cincinnati anticline (Plate 22) suggests that the fossiliferous part of the section immediately above the Bardstown coral bed in central Kentucky is the southern, attenuated extension of the richly fossiliferous section forming the lower part of the Richmond at Mount Washington, and at Bull creek. But the fossiliferous part of the sections at Mount Washington and Bull creek is evidently of Lower and Middle Richmond age, and occurs below the Madison coral reef horizon. For the present, therefore, the conclusion is drawn that the formation of the Bardstown coral reef was not synchronous with that of the Madison reef.

A further examination of the accompanying sections will show that the Bardstown coral reef has been assumed to be the base of the Richmond stage in central Kentucky. This was done because at numerous localities characteristic Richmond fossils were found immediately above the coral reef, and no Richmond group brachiopods were found in the layers immediately beneath. At several localities, one or two specimens of *Streptelasma rusticum* and *Protarea vetusta* were found several feet below this coral bed. At some localities there are several coral beds, several feet apart or even at greater intervals, containing *Columnaria alveolata, Columnaria halli, Tetradium minus,* and occasionally even *Calopoecia cribriformis.* It then becomes difficult to determine where to draw the line between the Richmond and the Lorraine. The massive corals appear to have a greater vertical range in central Kentucky than in Ohio and Indiana. At several localities *Streptelasma rusticum* occurs several feet lower than any other fossil usually

considered characteristic of the Richmond stage. As a rule the lowest strata containing characteristic Richmond brachiopods or the coral bed immediately beneath, wherever any coral bed occupied this position, was regarded as forming the base of the Richmond section. Much new light will undoubtedly be shed upon this question when the bryozoans, the most valuable horizon markers of the Ordovician, are more fully studied.

The Upper Richmond.

At Madison, Indiana, the greater part of the Upper Richmond consists of the nearly unfossiliferous, massive, banded, argillaceous limestone which forms a conspicuous element at all waterfalls and other steep cuts near the upper part of the hills. This rock can be distinguished readily from any other rock in the section. Southward it can be traced with ease as far as Charlestown Landing in Clark county in Indiana. Typical exposures occur at numerous localities in Oldham, Jefferson, and Bullit counties, in Kentucky. The exposures of the massive limestone at the top of the Ordovician section south of Mount Washington, and at the Asa Lutes and Kirby Jones localities are lithologically identical with those along the Ohio river in the southern part of Indiana. Similar rock is also found south of the Kirby Jones locality, in Nelson and Marion counties, Kentucky. Here, however, the thickness of the Upper Richmond section is much less, and the massive rock forms a less conspicuous part of the section. It has not yet been definitely demonstrated that the richly fossiliferous beds above the Bardstown coral reef in Nelson and Marion counties belong to the Middle and not to the Upper Richmond. At present, however, they are regarded as of Middle Richmond age, and the base of the immediately overlying, nearly unfossiliferous portion is regarded as the base of the upper Richmond.

C. Conclusions.

The following conclusions are offered as perhaps the most reasonable in the present condition of our knowledge.

The Lower Richmond diminishes in thickness from Fort Recovery in western Ohio, southward. West of the Cincinnati uplift, the last traces of the *Dalmanella jugosa* zone are seen at Marble Hill in southern Indiana. The upper part of the Lower Richmond can be readily identified at the mouth of Bull creek; it is probably present at Mount Washington and

at other localities in the immediate vicinity of Salt river, but farther south, in Nelson and Marion counties, it seems to be absent. On the eastern side of the Cincinnati uplift, the *Dalmanella jugosa* zone is fully represented at Concord, in Kentucky. It disappears at some point north of Owingsville. The upper part of the Lower Richmond has been detected at Spencer,* and it unquestionably extends farther southward.

The Middle Richmond also diminishes in thickness southward. West of the Cincinnati uplift the Middle Richmond has been recognized as a distinct formation as far south as the mouth of Bull creek in southern Indiana. The fossils belonging to this horizon, however may be traced much farther southward. Middle Richmond fossils occur at Bardstown in Nelson county, and at other localities in Nelson and Marion counties. It is believed that the Middle Richmond has a greater southward extension in central Kentucky than the Lower Richmond. East of the Cincinnati uplift the Middle Richmond is well exposed near Concord, Kentucky. In central Kentucky the corresponding horizon seems to consist of argillaceous, nearly unfossiliferous rock, and it may apparently be traced as far south as Shelby City, four miles south of Danville.

The Upper Richmond also diminishes considerably in thickness southward, but its thickness in Nelson and Marion counties is sufficiently constant to suggest an extension of this formation into southern Kentucky. It is probable that the Richmond exposures along Fishing creek, west of Somerset, and along the Cumberland river, east of the Cincinnati uplift belong to this horizon.† *Hebertella sinuata, Byssonchia radiata, Pterinea demissa*, and *Streptelasma rusticum* may occur in any part of the Richmond, but the forms of *Platystrophia* along Fishing creek resemble more the small variety with a hingeline scarcely exceeding the width of the shell, occurring in the Upper Richmond, than any form commonly found in the Middle Richmond.‡

If these conclusions are correct, the Middle Richmond extended farther south, in central Kentucky, than the Lower Richmond, while the Upper Richmond probably reached nor-

* "The Cincinnati anticline in Southern Kentucky." AMERICAN GEOLOGIST, 1902, vol. xxx, p. 368.

† *Ibid.*, p. 304.

‡ "The Morphogenesis of Platystrophia," E. R. CUMINGS, p 25.

thern Tennessee. Sufficient data are not at hand, as yet, to determine whether these formations diminish in thickness on being traced from the flanks toward the crest of the present Cincinnati uplift.

The southern extension of the upper half of the Lorraine, in central and southern Kentucky, is much more argillaceous and siliceous than the northern portion, in Indiana and Ohio. It also contains a much smaller number and variety of fossils. At many levels and at many localities there is evidence of deposition during shallow water conditions. There is abundant evidence that at the close of the Lorraine these shallow water conditions extended northward into Indiana and Ohio.

At Marble Hill, the socalled marble stratum forming the top of the Lorraine consists of 11 feet of white, massive limestone almost entirely composed of rolled fragments of thick-shelled gasteropods and lamellibranchs, swept together by some powerful current. The top of this stratum is strongly wavemarked, the trend of the ridges being ten degrees east of north. This stratum has an extension of at least ten miles. About five and a half miles south of Versailles, the top of the Lorraine is formed by a wavemarked layer of limestone. The lowest Richmond beds at Lebanon, Ohio, are wavemarked. Numerous other instances of wavemarking at this horizon might be given.

Another evidence of shallow water conditions at the close of the Lorraine in Indiana and Ohio consists in the frequent occurrence of nodular clay or of nodular clayey limestone at the top of the formation. This is especially characteristic of the top of the Lorraine along its line of outcrop in Ohio, but may be seen also at many localities in Indiana.

Shallow water conditions are in evidence also at many levels in the Richmond stage throughout Indiana and Ohio. The great thickness of the Richmond stage along the northern line of outcrop in Indiana and Ohio as compared with the thickness in central Kentucky was probably due to a long continued progressive depression of the sea bottom in the more northern area, while the elevation of the sea bottom may have continued for some time after the close of the Lorraine in central Kentucky. At least, the rate of depression in the southern area may have been much less.

Western Ohio and eastern Indiana appear to have been an area of long continued progressive depression during the deposition of the entire Cincinnati series. Evidences of shallow water conditions are found at all levels within this series.

The numerous borings for gas and oil in western Ohio* have shown that the Cincinnati series reaches its greatest thickness in the most eastern wells, along a line extending between Fayette and Ottawa counties. Conditions east of these counties are unknown. From the line which joins the most eastern wells, westward, the thickness diminishes everywhere. The wells in Indiana† show that this diminution in thickness continues across the state of Indiana into northern Illinois and southern Michigan. The outcrops of Ordovician strata in western and southern Illinois and in Missouri indicate a diminution also in that direction. This suggests that the area in western Ohio and eastern Indiana was a region of maximum subsidence during the deposition of the Cincinnati series. During this period the areas is southern Kentucky and northern Tennessee, and in western and northern Illinois were regions of less subsidence or at times possibly even of elevation.

The wells in Ohio and Indiana do not indicate a decrease in thickness of the Cincinnati series from the flank towards the crest of the Cincinnati uplift along the western side of its present extension into these states. This suggests that the origin of this part of the Cincinnati uplift may be of later date than the close of the Ordovician. Sufficient data have not yet been collected in Kentucky to determine whether the very evident dome which now exists in north central Kentucky was already in existence in Ordovician times. The Cincinnati uplift may have originated in southern Kentucky and northern Tennessee. The low fold which now extends, with a trend of 25 degrees east of north, from Tennessee through central Kentucky may have been due to subsequent epeirogenic movements. Its northern extension into Ohio and Indiana may have been of still later date. It is evident that a much greater accumulation of facts is needed before deductions can be made which will have any value excepting as offering suggestions of subjects for future investigation.

† *Geology of Ohio*, vol. vi, 1888.

† 'Studies of the Indiana Natural gas field." FRANK LEVERETT, AMER. GEOL., vol. iv, 1889, p. 6.

The shallow waters surrounding this area of long continued, progressive subsidence contained a wealth of animal life. This life, owing to geologic causes not yet definitely worked out, was subject to migrations. The character and direction of these migrations is certain to prove a subject of investigation in the near future.

As a result of these migrations, some species entered the field here under investigation, and, after a brief existence, disappeared again.

For instance, at some time previous to the Cincinnati epoch, the genus *Strophomena*† disappeared from southern Ohio, Indiana, and Kentucky. In the lower Utica, *Strophomena halliana* is a rare fossil. At the close of the deposition of the Mount Hope beds, *Strophomena planoconvexa* entered the field, and, after forming part of a layer a few inches thick in the vicinity of Cincinnati, it disappeared again. A little later, during the deposition of the Fairmount beds, *Strophomena sinuata* had a nearly equally brief existence. No other Strophomenas are known until the base of the Richmond stage is reached. *Strophomena planoconvexa* and *Strophomena sinuata* belong to different sections of the genus. Nevertheless their occurrence within fifty feet of one another separated by considerable intervals from other horizons containing Strophomena may have some significance, since this suggests the possibility of brief connections of the sea near Cincinnati during the earlier Lorraine with some other area in which the development of the genus Strophomena was more continuous. It would be interesting to know from what source the species migrated towards Cincinnati. The forms identified as *Strophomena planoconvexa* near Maysville, Kentucky, have a vertical range of fifteen feet, being very abundant in the lower six feet, while the typical forms at Cincinnati have a range of only a few inches. During the deposition of the Richmond, connection with the region from which *Strophomena sinuata* and *Str. planoconvexa* migrated may have been established again, the first species being represented in the Richmond by *Strophomena sulcata,* while the latter is represented by an undescribed species differing only in its greater width and shorter length.

† "The Lower Silurian Deposits of the Upper Mississippi province. WINCHELL and ULRICH, 1897, *Geol. Minn.*, vol. iii, part 2, pp. cili, civ, also 384-396.

The section of the genus represented by *Strophomena nutans, Str. rugosa, Str. subtenta, Str. vetusta,* and *Str. neglecta,* may have entered the Cincinnati area from some other direction. No species representative of this section have so far been discovered in the Utica or Lorraine in the area under discussion. The greatest number of closely related species known is found in the Trenton and Cincinnati series towards the northwest, in Minnesota and neighboring states.

The genus *Dinorthis* is unknown in the Cincinnati series of the Cincinnati region until the middle of the Warren bed is reached. Here *Dinorthis retrorsa* is found. At Madison in Indiana the vertical range is confined to a few inches of clay. Along the northeastern line of outcrop in Ohio it has a vertical range of several feet. Its nearest relative is a smaller form occurring in the Trenton at Ottawa in Canada. *Dinorthis scovillei* and *D. subquadrata* may represent migrations from the northwest. At any rate the most complete series of forms intermediate between *Dinorthis subquadrata* and the Trenton representatives of this genus so far known occur in Minnesota and neighboring states.*

Between *Hebertella bellarugosa* in the Trenton and *H. insculpta* at the top of the Lower Richmond, there is a great interval, but both species are distinctly western.† The narrow vertical range of *Hebertella insculpta* in Ohio and Indiana suggests its introduction into the fauna of those regions through migration. *Hebertella occidentalis,* which occurs in the Middle and Upper Richmond, is also a distinctly western species.

Catazyga headi, on the contrary, finds its nearest relatives towards the northeast.

The massive corals, *Columnaria alveolata, Columnaria halli, Calopoecia cribriformis,* and *Tetradium minus* are essentially Trenton forms which are absent in the lower and middle parts of the Cincinnati series, but are abundant at certain levels in the upper part of the Cincinnati group. This is also true of *Protarea vetusta* and *Streptelasma rusticum.* Their migration during the later part of the Cincinnati epoch was probably from the north, but there is nothing to suggest whether from the northeast or the northwest.

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* *Ibid.*, pp. 424-431.
† *Ibid.*, pp. 434-435.

Beatricea undulosa and *Beatricea nodulosa* range from the Trenton nearly to the top of the Ordovician on the island of Anticosti, but in Kentucky they are found only near the top of the Lorraine and in the Richmond.

The preceding observations suggest that an important part of the fauna of the Richmond stage, as represented in Ohio, Indiana, and Kentucky, was not developed from the Lorraine fauna of the same area but entered this field from some more northern territory as the result of migration. This part of the Richmond fauna has a distinctly Trenton facies. Since the greater number of varieties intermediate between the characteristic Trenton species and their Richmond representatives appear to be preserved in the Trenton of the northwestern states, Minnesota, Iowa, Illinois, Wisconsin, Manitoba, and in the Trenton of Ontario and eastern Canada, it seems probable that this part of the Richmond fauna was developed chiefly north of the present Ohio basin, and presumably within the territories designated. From these territories that part of the Richmond fauna here under consideration appears to have entered the Ohio basin by at least two routes: one from the northwest bringing in the *rugosa* group of *Strophomena, Dinorthis subquadrata,* and possibly *Hebertella insculpta,* and another from the northeast, bringing in *Dinorthis retrorsa,* and *Beatricea.* The migrations from the northeast appear to have begun in the latter part of the Lorraine, and to have taken a path which was cut off from New York, so that the Richmond fauna did not enter that state or the Appalachian region.* The migrations from the northwest appear to have begun later but to have been more influential in determining the chief characteristics of the Richmond fauna. The derivation of the typical Richmond fauna from some more northern areas is not inconsistent with the existence of some of the Trenton ancestors within the Ohio basin during Trenton times, since the Trenton fauna may have retreated towards the north at the close of the Trenton, and given way to the Utica fauna which marks the beginning of the Cincinnati epoch.

Some of the forms of brachiopods occurring in the Cincinnati series of the Ohio basin are probably largely the result

* Paleozoic seas and barriers. ULRICH and SCHUCHERT. *Report of New York State Paleontologist* for 1901, published in 1902, No. 2.

of local development. The great variety of closely related forms of *Plectorthis* in the Lorraine, near Cincinnati, suggests that these species were largely differentiated in the area under consideration. This is also true of various forms of *Zygospira, Dalmanella,* and *Platystrophia* in various parts of the Cincinnati series. The various forms belonging to the group of *Strophomena rugosa,* which occur in the Richmond series, were also probably differentiated in part in the area in question. They show variations sufficiently distinct to warrant specific names, but they are connected by numerous intermediate forms.

AN OLD PLATTE CHANNEL.

By G. E. Condra, University of Nebraska.

The region considered in this paper is a shallow valley some twenty-eight miles long and six to eight miles wide extending across Saunders county from northwest to southeast. The nature of this country with its rich agricultural resources is slowly coming to be better understood by the prosperous residents. As yet, the region has not been named. To the south, about Wahoo and Mead, it is by some erroneously called the Wahoo valley. To the north, near Morse Bluff and Cedar Bluffs, it is quite generally confused with the Sand creek valley. This incorrect use of terms is due to the fact that Wahoo creek, and Sand creek, a tributary of the former, have cut a shallow trough in and along the western side of the nameless valley. The name Wahoo does not properly apply to both troughs; while such usage is not general, the name Wahoo should be restricted in use so that it will stand for the valley produced by the creek of that name. The same might be said of the use of the term Sand creek. It does not seem best to propose the names Greater Wahoo and Lesser Wahoo. A name that indicates occupation by an Indian tribe or stands for effective service by some geologist should be selected. The writer prefers the latter, and at the suggestion of professor E. H. Boohour, state geologist, herein proposes the name "Todd valley" in honor of professor J. E. Todd of Vermilion, South Dakota, who has given much time to a study of the drift of this locality.

Data on which the paper is based have been collected from a number of sources extending over a period of ten years. In 1893, while passing from York to Fremont over the Chicago and Northwestern (Formerly F. E. & M. V.) railroad, the break or gap in the bluffs between Morse Bluff and Cedar Bluffs was observed and noted. Later, and at different times while traveling between Lincoln and Fremont over another line of the same railroad, as well as to and from Valley over the Union Pacific railroad, my attention has been directed to the valley with its bordering highlands which show a quick change in topography. The C. & N. W. railroad passes obliquely across the valley between Wahoo and Cedar Bluffs a distance of twelve miles, while the U. P. railroad traverses the valley between Wahoo and Mead a distance of about six miles. On the Fremont topographic sheet Mead is incorrectly given as Marietta. Marietta is a precinct northwest of Mead.

The writer has made trips with a team and on foot to practically all points shown on the accompanying map. Superintendent J. W. Searson of Wahoo has assisted me in making the acquaintance of well men in different towns. The most valuable well records were obtained from I. S. Crawford of Wahoo, E. G. Adell of Yutan, and J. G. Martin of Cedar Bluffs.

C. A. Fisher, in 1898, mentioned and briefly described the valley in his second degree thesis, "Geology of Saunders County." The relief map published by N. H. Darton, 1898, plainly shows the region (See 19th Ann. Rep. U. S. G. S., Pt. IV, Pl. 75). Wahoo, and Fremont topographic sheets from which the accompanying map was drawn, show the surface conditions in detail. Professor J. E. Todd, in Bull. 158 U. S. G. S., 1899, gives valuable data on stratigraphy and topography as well as the probable origin of the valley which we are at present considering.

Topography.

General.—The map, or Fig. 1, shows two lowland areas and the highlands. Two distinct types of topography, differing in origin, are represented. The flood plain or valley floor of the Platte, and the floor of Todd valley constitute the lowlands; the latter, however, is somewhat elevated at the north-

ern end. There are three highland areas only one of which concerns us much at this time.

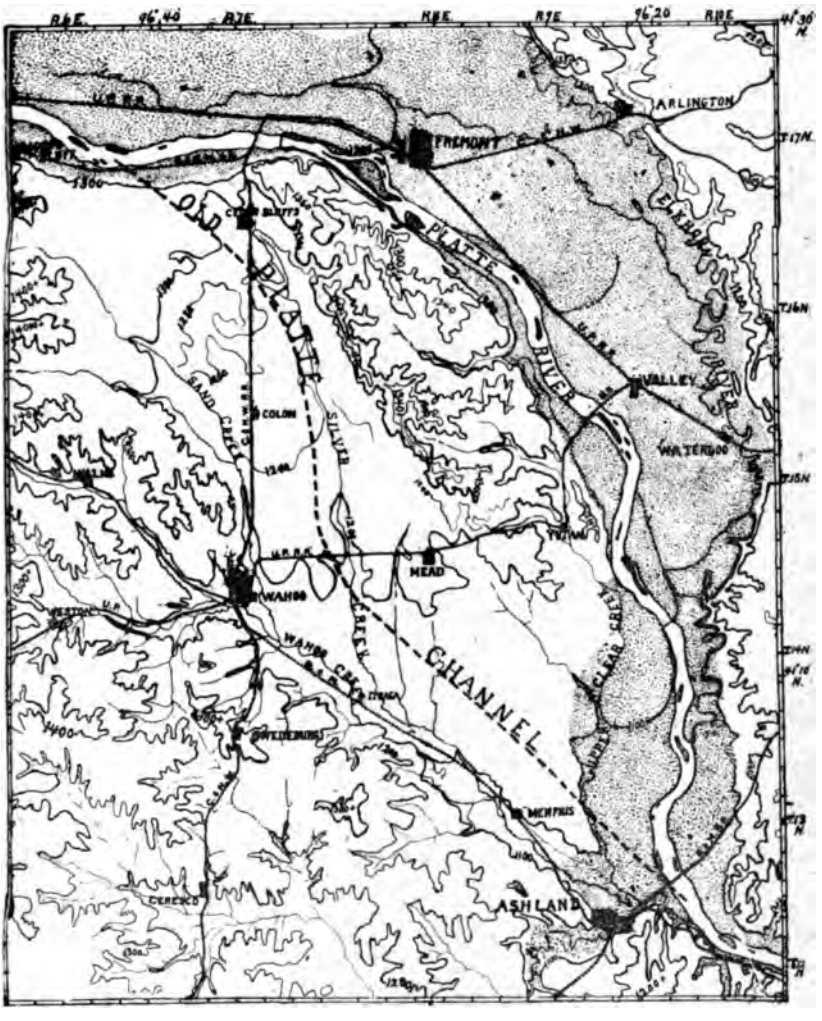


FIG. 1.

The Platte and Its Flood Plain.—The Platte is a broad, shallow, and over-loaded river. It is further characterized by numerous sand bars and low sandy islands. The floor is quite level, little dissected, and imperfectly drained. Overflow channels and low sinuous, sandy ridges show where the

stream has swept across the flood plain carrying away surface soil and sand. These irregularities are produced by cutting where the grade causes an increase in velocity; where the velocity is decreased, deposits accumulate at flood time. When the ice "goes out" in the spring, gorges form at places causing overflows. Then it is that the Platte is most erratic.

Small sand dunes resulting from wind action occur near Fremont and Valley. The flood plain varies much in width, being ten miles wide at Fremont and about one mile wide below Ashland where the river strikes the resistant Coal Measure beds. The inference, that the Platte by building up a steadily rising flood plain, has crowded the Elkhorn eastward and southward is quite generally drawn.

Todd Valley.—This valley, shut in on both sides by bordering hills, opens at each end into the Platte valley of which it seems to be a part. The altitude at the northern end is 1300 to 1340 feet or 60 to 100 feet above the Platte; at the southern end, it is 1120 to 1140 feet or 20 to 40 feet above the Platte floor. The gradient averages about seven feet to the mile. The floor averaging 80 to 100 feet below the bordering highlands, is for the greater part, level, not much dissected, and poorly drained, showing here and there low knoll-like elevations with intervening wet-weather ponds. Except a few shallow sloughs, the only irregularities of any consequence occur along Wahoo creek, and Sand creek. At each end the valley floor presents the appearance of a rounded terrace.

The Highlands.—Except for the gradual ascent to the north and west, the highlands lie in the same general level. They are considerably elevated above the regions already described and show a hilly or older topography. Between the Platte and the Todd valley is a region three to six miles wide and over twenty miles long extending in a southeasterly direction from near the high bluffs northeast of Cedar Bluffs to a point south of Yutan. This well drained hilly region, with a distinct divide, and occurring between the comparatively new lowland areas, has an important bearing in the subject under consideration. It seems to be a separated portion of the other highlands.

Conclusion.—The surface indications cause one to believe that the Platte river at one time flowed through Todd valley and that it has been diverted to its present position.

Stratigraphy.

General.—Since most slopes are covered by loess the number of rock-bed exposures is small. In the region of Ashland, Coal Measures strata and the Dakota sandstone come to the surface at a number of places along the Platte and Salt creek. Both of these formations dip slightly to the northwest where the latter is overlaid by the Benton which is exposed near Morse Bluff and reached in a boring north of Cedar Bluffs. J. G. Martin, while sinking a test well at the foot of the bluffs near the southern end of the C. & N. W. bridge struck a shaly coal (Benton) at a depth of 100 feet.

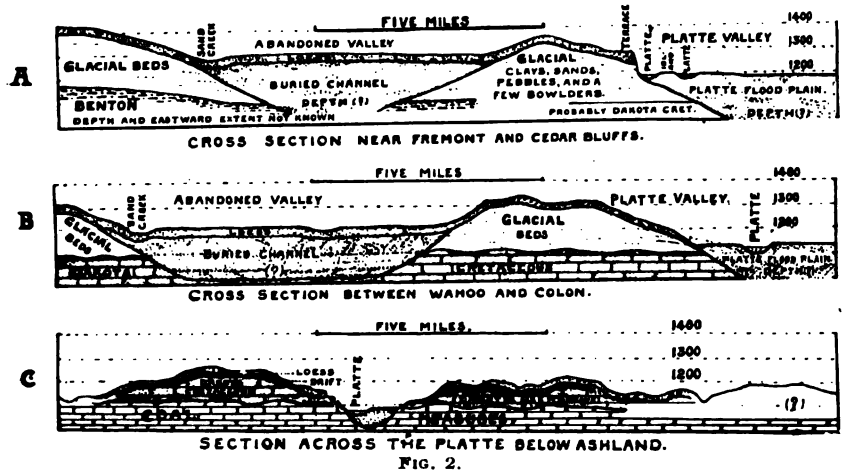


FIG. 2.

The drift is a variable quantity; it may lie on either of the formations named, varying with the locality. Stratified clays and sand predominate in the region of Fremont, while bowlders increase in number and the amount of clay and sand decreases to the south and southwest.

Except for the flood plain of the Platte and a few places on the steepest hills, the loess forms a thin veneer over the country, concealing other deposits and thereby making it all the more necessary to use well records as evidence.

Platte Flood Plain.—Here the soil forms a thin surface layer beneath which is sand varying in thickness from about sixty feet, below Ashland, to 200 or 300 (?) feet at Fremont. Thin seams of clay and quicksand are at times encountered.

NOTE.—"Abandoned Valley" should read Todd Valley.

The sand averages coarser as the depth is increased. Passing northward or up the river from Ashland, the flood plain is underlain by beds belonging to the Coal Measures, Dakota, and Benton. Glacial clays dip beneath the river at a number of places.

Todd Valley.—The following from I. S. Crawford gives the conditions in the floor of this valley: "During the past twenty years we have put down wells throughout the whole of Saunders county. In this valley we go through three or four feet of soil, twenty feet or more of loess, and then sand. The sand is quite fine above and coarse below, approximating fine gravel in size. Fifteen to twenty feet of the upper sand is dry. The lower beds are alternations of fine and coarse sand. The water level fluctuates no more than twelve inches between wet and dry seasons. Water is found at the same general level showing a slope to the southeast of six or seven feet to the mile. Depth to water line about forty feet. It is necessary at times to run a point down forty to sixty feet below this level in order to obtain a good position for the point and the best well. These conditions hold good throughout the length and breadth of the valley, except on the highest places, where the sand reaches to within a few inches of the surface." J. G. Martin has not penetrated the sand in wells 190 feet deep.

L. J. Pospisil states the following. "Rarely do well diggers penetrate the sand which is fine above and coarse below, as it is along the Platte. On the place of Mr. Minas four and one-half miles northeast of Wahoo, a well sunk to a depth of 120 feet did not pass through the sand."

The Highlands.—An examination of the bordering hills gives additional facts from which certain conclusions may be reached. The region with which we are most concerned is the highland between Todd valley and Platte valley. Sections A and B, Fig. 2, represent the general arrangement and probable thickness of beds. A well on the place of Hon. E. J. Harmon, four miles east of Cedar Bluffs, in a level of 182 feet above the river, is 185 feet deep. Soil, loess, and glacial clay, with sands and a few harder beds were encountered in the well. Mr. Harmon's notes indicate the presence of a shaly limestone just above the river level. This bed may be a blue glacial clay associated with a chalky layer. Otherwise, it belongs to the

Benton which has been reached at a lower level seven miles northwest. A few miles south of E. J. Harmon's place, on T. 16, R. 8, Sec. 36, I. S. Crawford put down a well 323 feet and gives the following report: "Soil, 4 feet; loess, 20 feet; clay of different colors with occasional harder beds, 136 feet; sand with some water, 8 feet; ocher, varying in color, usually red to yellow, 115 feet; hard sandstone, hard above, softer and coarse below, 40 feet. Supply of water unlimited. Another well one mile south is the same except depth. The description is the same for all wells in this highland region. Water rises 160 feet." According to this record, Benton beds do not occur here The ocher beds, it is believed belong to the Dakota. E. G. Adell gives similar reports for wells put down by his men, but finds twenty to fifty feet of loess. Neither of these gentlemen has encountered bowlders of any size while sinking wells here.

In the cut banks southwest of Fremont, the following generalized section shows in whole or in part at a number of places: Bluish clay mingling above with till and passing under the river below, depth not known; till containing clay, pebbles and a few bowlders, thickness variable, usually a few feet; reddish clay containing pebbles and sometimes small bowlders, thickness at places twenty feet; light colored clays blotched with red, containing many concretions and pebbles, thickness 2 to 10 feet; red clay, 10 to 15 feet; loess 25 to 50 feet.

Near the southern end of the wagon bridge south of Fremont and a few feet above the river, an irregular bed of friable sandstone colored by iron, is overlain by till. Other thin beds with limited extent occur at places. Professor Todd in Bull. 158, U. S. G. S., 1899, p. 79, published the following typical section from this vicinity.

	Ft.	In.
Loess, the dark line three feet above its base appearing only as thin wavy streaks	30	0
Red clay passing into drab and rusty below	11	0
Whitish clay with many chalky concretions and numerous pebbles, some of them scratched. This deposit ends abruptly at one end and at the other tapers out	2	0
Similar reddish and drab clay with pebbles, but with few if any bowlders	22	0
Light greenish clay, blotched with white, extending horizontally at least a rod. Its ends are hidden	1	2

Reddish clay, passing below into twenty feet till which is yellowish above, but the blue color rises in places near the top..... 11

Level of the river.

In speaking of the highlands west and south of Todd valley, I. S. Crawford states: "The formations in the highlands west of the valley are nearly identical with those to the east, but water rises within a few feet of the surface. These conditions hold good for wells as far west as R. 6 and to the south line of T. 14, beyond which the conditions vary. We get flowing wells in the southwestern corner of the county; also, saline wells, but not too salt for stock, in a sand rock in T. 13 east of the west line of R. 6."

Conclusions.—The observations enumerated, if understood, indicate the presence of a flood plain buried beneath the loess in Todd valley, and show that it is nearly identical in structure with the Platte flood plain. The highlands are very unlike the flood plain of Todd valley in structure. Rock beds of the former occur in a higher level than the buried channel. That the valley was eroded in Glacial, Benton, Dakota and Probably Coal Measures beds, is quite apparent.

Origin of Todd Valley.

All evidence cited goes to show that the valley was produced by the Platte river at an earlier period. The topography and stratigraphy both indicate that fact. The elliptical highland cannot be a river-island such as now occur at a number of places along the river. The structure is identical with the other highlands from which it has been separated by erosion. It denotes a distinct change in the earlier course of the river. Just what the history of that change in drainage is, I do not know. Neither do I understand the causes of the diversion. The question is a complicated one. Professor Todd, in Bull. 158, U. S. G. S., 1899, p. 143, writes the following: "The relations of the high terrace of the Platte river to the highland in the vicinity of Fremont, Nebraska, suggests that the diversion of the old channel across Saunders county may have been due to its cutting through the divide which formerly separated the Platte from the Elkhorn, and that this was subsequent to the formation of the terrace." Slow elevation to the west at that time must have given the river increased velocity which may have caused it to cut through the divide.

The fact that the old channel was eroded, for the most part, in glacial beds evidently precludes (unless there have been two advances of the ice in Nebraska) the idea that the Platte was dammed by the ice sheet in the region of Fremont and thus caused to overflow southward for a time along the axis of the buried channel. This condition seems to show that the valleys are post-glacial in origin. The presence of twenty feet of loess covering the level flood plain shows that the river has not occupied the valley since the last of that bed was deposited. The rather mature Wahoo valley, between Wahoo and Ashland, is an example of how much work a small post-loessan stream has done in soft beds.

While it is quite generally thought by geologists that this part of the Platte valley is of pre-glacial origin, there is very little evidence to warrant such a conclusion. I do not know that any portion of the lower narrow course of the Platte trough was in existence pre-glacially. Certain conditions cause me to think that the valley may be older at Fremont than at South Bend and that a deep pre-glacial channel may extend southeastward from Fremont and Valley to the Missouri river. The stratified clays and sands there may represent frontal wash in a broad pre-glacial valley or basin.

RELATIVE AGE OF THE LANCE CREEK* (CERATOPS) BEDS OF CONVERSE COUNTY, WYOMING, THE JUDITH RIVER BEDS OF MONTANA AND THE BELLY RIVER BEDS OF CANADA.

By J. B. Hatcher, Carnegie Museum, Pittsburg, Pa.

In their memoir entitled "On Vertebrata of the Mid-Cretaceous of the Northwest Territory," published as Part II, Vol. III, of "Contributions to Canadian Paleontology" (Ottawa, September, 1902), professors H. F. Osborn and L. M. Lambe have made an important addition to our knowledge of the vertebrate fauna of the Belly River beds. Many new species of fishes, batrachians, turtles, crocodiles, dinosaurs and mammals have been described and illustrated with most excellent figures.

* The name Ceratops beds cannot be used for these Wyoming deposits, and I give to them the above name, from the principal stream in the region where they are best represented in Converse county, Wyoming.

While this publication forms a welcome addition to the literature on American fossil vertebrates, not the least interesting portion of it is that by professor Osborn on the "Distinctive characters of the Mid-Cretaceous Fauna," and the introductory remarks of professor Lambe referring to the stratigraphy and geology of the beds and region from which the material described by him was obtained.

Professor Osborn opens his discussion with the remark that "the determination by the Canadian Survey of a Mid- Cretaceous and fresh-water fauna, including fishes, batrachians, reptiles and mammals, is a forward step of great importance in vertebrate paleontology." He points out that the survey has established beyond question on stratigraphical evidence the fact that the Belly River beds underlie the Montana or Pierre-Fox Hills group. He next points out the similarity in character between the faunas of the Belly River beds of Canada and the Judith River beds of Montana, notices the more primitive nature of the faunas of both these series of deposits when compared with that of the Lance Creek (Ceratops) beds of Converse county, Wyoming, and arrives at the conclusion that "the fossil vertebrates hitherto described from Montana probably are, in part at least, of Mid-Cretaceous of Belly River age." This is a very notable and to my mind very proper conclusion, considering the fact that it was based entirely upon paleontological evidence, its author believing at that time that such stratigraphical evidences as did exist were directly opposed to such a conclusion, stating that "the geological records all place the Judith River beds proper above the Fox Hills and Fort Pierre." The present writer has since called attention to the fact that the exact stratigraphic position of the Judith River beds relative to the Fort Pierre and Fox Hills is yet to be definitely determined,* and that there is at present not a little evidence in favor of their lowermost members occupying a position below the Pierre which would favor the correlating of that portion of them with the Belly River series, as was originally proposed by Dr. G. M. Dawson.

I am aware that the late professor Cope regarded the Judith River beds as overlying the Fox Hills and stated (p. 569, Bull. U. S. G. and Geogr. S. Terrs., Vol. III.) that "In the

* *Science*, N. S., vol. xvi, pp. 831-832.

Judith region the relations of the Fox Hills sandstones to the superincumbent strata is everywhere observable." After a personal examination of this region, however, I am convinced that the actual stratigraphy is not as simple as the text and published sections of Cope would indicate. Moreover he himself mentions the finding of dinosaur remains and Fox Hills invertebrates in the same stratum in this region.

Osborn points out the fact that, while the Belly River and Judith River faunas include many identical species, there is very little in common between them and the Lance Creek beds of Converse county, Wyoming. He recognizes in the material from the Montana (Judith River) beds, types which are older than the Laramie, and suggests some confusion in the collections and that several horizons may be represented in collections that have generally been referred to the Judith River beds. The entire discussion of this question is, in every sense, admirable and one cannot help appreciating the methods by which he has arrived at what seems a correct solution of the problem in spite of what may prove to be somewhat erroneous ideas as to stratigraphy. It is a clear vindication of the perfectly trustworthy nature of the evidences furnished by certain classes of fossil vertebrates for purposes of correlation.

After this very decided advance toward a satisfactory adjustment of the Laramie imbroglio it is with somewhat different feelings that one turns to a recent note in *Science* by Dr. S. W. Williston, entitled "The Laramie Cretaceous of Wyoming."* After noting professor Osborn's conclusion that a portion at least of the Montana deposits previously referred to the Laramie may really be Mid-Cretaceous† in age and contemporary with the Belly River beds, and a similar opinion previously expressed by the present writer, Dr. Williston says: "The Laramie deposits of Converse county, Wyoming, have usually been placed at the end (close) of the Fox Hills, but I am somewhat skeptical of this. I believe that future research will show that not only the Judith River beds, but also those of Wyoming, will be found to be contemporary, in part at least, with the Fox Hills deposits, and that they are not separated by so great an interval from these other (which other?) de-

* *Science*, *N. S.*, vol. xvi, pp. 952-953.

† By Mid-Cretaceous I do not mean Middle Cretaceous, but as being underlain and overlain by deposits clearly pertaining to the Cretaceous.

posits which have hitherto been supposed to be contemporaneous.

"This conclusion I base largely upon the fauna of the Wyoming beds, which present, in some respects at least, a startling resemblance to that of both the Judith River and Belly River series.

"Not only a number of genera, but also a number of species previously described from Montana and now recognized by Lambe in the Belly River deposits, occur here in the supposed later deposits of Wyoming. It would seem almost incredible that so many of these should have persisted unchanged through the long interval represented by so many thousand (!!!) feet of Fox Hills deposits, to say nothing of the Fort Pierre."

Dr. Williston also calls attention to the fact that the late professor Marsh made no mention of a number of interesting fossils from the Laramie of Converse county, Wyoming, which must have been known to him, and infers from this that Marsh believed them identical with others already described from the Judith River beds which he believed of equivalent age. Among such forms Williston mentions as occurring in the collections from the Converse County Laramie, now in the museums of Chicago University and of the University of Kansas, the following, which he is unable to distinguish either generically or specifically from the Judith River and Belly River forms:

Myledaphus bipartitus Cope, represented by isolated teeth.

Accipenser (sic) albertensis Lambe, represented by fragments of shield.

Lepidosteus (*Lepidotus*) *occidentalis* Leidy, represented by detached scutes.

Crocodilus humilis leidy, detached teeth, scutes and isolated vertebræ.

Scapherpeton tectum Cope, scattered vertebræ and mandibular fragments.

Champsosarus, Cope, scattered vertebræ.

Aublysodon explanatus Cope, detached teeth.

Paleoscincus asper Lambe, detached teeth.

Baena hatcheri Hay, carapace and plastron.

With this general statement as to Dr. Williston's views regarding the actual and relative ages of the Lance Creek (Ceratops) beds, Judith River and Belly River beds, let us proceed

to examine a little more in detail the reasons he has assigned for his opinions.

First, as to the doubt which he expresses as to the stratigraphical position of the Laramie beds of Converse county, Wyoming, being at the end (close) of the Fox Hills. I am somewhat surprised at this expression of doubt on the part of Dr. Williston regarding the actual position relative to the Fox Hills of these beds in Converse county since I am well aware of his ability as an observer and of the fact that he himself at one time passed several weeks collecting from these beds, and that he should, therefore, be familiar with the stratigraphy of the region. Since I myself passed nearly four full years in collecting from these beds I may perhaps presume to speak with some authority on this subject. I have already described* the stratigraphy and sequence of the various formations of this region, and need only remark here that many good sections exist and have been examined by the writer, commencing below with the Fort Pierre and continuing upward through the Fox Hills and the overlying Laramie, and on up into the Fort Union beds. The sequence and relative positions of the various horizons are extremely simple, the region being one which has undergone little disturbance either since or during the deposition of the beds, so that there is nowhere in the entire region any obscurity as to the proper sequence of strata due either to alternating marine and fresh-water conditions or to faults, overthrusts or other disturbances or dislocations in the beds. That these beds conformably overlie the Fox Hills in this region has been stated by the present writer in the publication just mentioned, and this statement has been abundantly corroborated by the investigations of doctors T. W. Stanton and F. H. Knowlton.†

Next as to the "startling resemblance" which Dr. Williston believes to exist between the fauna of the Wyoming beds and those of both the Judith River and the Belly River beds, and which he thinks could not have resulted from the Wyoming fauna's having persisted "through the long interval represented by so many thousand feet (!!) of Fox Hills deposits, not to mention the Fort Pierre." Where, I should like to ask, does

* *Am. Journ. Sci.*, vol. xlv, pp. 135-144, Feb., 1893.
† *Bull. Geol. Soc. Am.*, vol. viii, pp. 128-137.

Dr. Williston find any such thickness given for the Fox Hills as that which he mentions here? Even the thickness of 3000 to 4000 feet at one time ascribed to it by King is now known to be much too great, the real thickness scarcely, if at all, exceeding 500 feet. Perhaps if he reduces the thickness of these beds to their usually ascribed limits the persistence of certain types of animals will not then seem so "incredible" as he had at first supposed; although I do not for a moment wish to be understood as accepting the evidence brought forward by Dr. Williston from the fossils as of anything like the importance which he attaches to it.

Such paleontological evidence as he does present in support of his position is, to my mind, largely invalidated by two very grave objections. First of these is the fact that, as stated by Williston, in almost every instance the genera and species enumerated are represented by only fragmentary and isolated material, and hence their generic or specific identity cannot be determined with certainty. Second, several of the forms mentioned like *Baena, Lepidotus, Acipenser,* etc., pertain to persistent types which, even if their specific identity were not questionable, would still be of very little value for purposes of correlation.

Dr. Williston's inference that professor Marsh neglected to mention certain forms from Wyoming because he considered them identical with others already known from Montana is, I think, more logically explained by the very fragmentary nature of the remains and Marsh's well known aversion to dealing with fragmentary or relatively unimportant material and seeking after the "choicest plums," as he used frequently to express it. It is noticeable that in almost every instance in which he did treat of related forms from the Wyoming and Judith River Beds he considered them as both generically and specifically distinct; note, for example, the different forms of the Ceratopsidæ and Trachontidæ (Claosauridæ) described by him.

While there is, at present, some doubt as to the exact stratigraphic position, of the Judith River beds of Montana, it would seem that no such statement can be made as to the Belly River beds of Canada or the Laramie (Lance Creek) beds of Converse county, Wyoming. The stratigraphical position of

the former, it appears, has been definitely proven to be beneath the Fort Pierre and above the Benton, while that of the Converse county Laramie has been just as certainly shown to be above the Fox Hills and below the Fort Union. These are facts which cannot be ignored or set aside, and if they are not found to coincide with the previously formulated ideas of paleontologists, the error would seem to lie with the latter and not with the stratigraphy. In all such cases the sooner the paleontologist brings his theories into harmony with the facts of stratigraphy the better, for no amount of speculative correlation no matter how complete the material upon which it is based, and in this case the material is extremely fragmentary and unreliable, can upset exact stratigraphical determinations. Osborn and Lambe have shown conclusively that the fauna of the Belly River beds at least is decidedly more primitive than that of the Converse County beds of Wyoming, thus showing that the paleontological and stratigraphical evidences are in accord. They have also practically demonstrated what the present writer had for some years maintained, namely, that a portion of the Judith River beds at least are also older than the Wyoming beds. Their work, together with that of Douglass in central Montana, has furnished us with a key to the solution of the problem relating to the Laramie and earlier fresh- and brackish-water deposits of the Cretaceous of the west. Let us hope that in the not too distant future we may be able to fix with equal certainty the upper and lower limits of the Judith River beds, or perhaps differentiate them into two or more horizons such as it does not now seem impossible that they may contain, and definitely fix the limits and age of each.

Carnegie Museum, Pittsburg, Pa.,
December 15, 1902.

THE DETERMINATION OF THE FELDSPARS IN THIN SECTION.

By J. E. Spurr, Washington, D. C.

The accurate determination of the feldspars is of the greatest importance in accurate petrography. We have, unfortunately, no single publication where the different methods of optical investigation of minerals are given briefly and clearly for the guidance of workers without being buried in a mass of interesting but superfluous explanations. For this reason the writer long ago drew up certain summaries for his own use in microscopic work and he has found these of such value that he has been tempted to publish them for the help of others similarly situated. The short descriptions were mostly drawn up while the writer was studying the subject of feldspar determination in Germany and France. There is, of course, absolutely nothing original in them.

Becke Method of Determining Minerals, Especially Feldspar, by Their Single Refraction.

In any rock section find among the grains of the mineral to be studied, one with known orientation,—e.g. feldspar cut perpendicular to a bisectrix, as determined by convergent light. This grain must be in contact with a grain of some other mineral, preferably quartz, which should also have preferably a known orientation, although in quartz this is not so weighty as in biaxial minerals, since in every section the refraction parallel to the axis of least elasticity (ω) is constant. $n_{p\,na} = 1.544$.* Focus a high power lens on the contact of the two minerals. With raising of the lens, a dark band of total reflection migrates in the direction of the minerals of the highest refraction. This permits comparison of elasticities. Let polarized light from the lower nicol vibrate in the direction of an axis of elasticity in each mineral, of which axes the relative value (to other directions in same mineral) is known; observe which index of refraction is the greater; turn the section 90°

* n_p (*n* petit) is the French sign for the direction of least elasticity; n_g (*n* grand) is the direction of greatest elasticity; n_m (*n* moyen) is the direction of mean elasticity; $n_{p_{na}}$ signifies the refraction parallel to the direction of least elasticity, as observed in ordinary (sodium) light

and make the same observation. One such contact generally gives results reducing the feldspars to very narrow limits, and often determines the species exactly.

e. g. In one position one determines that in the feldspar $n'_g > n_p$ of the quartz, ∴ feldspar $n'_g > 1.544$.

In a position at 90° to the first one finds $n'_p > n_g$ i. e. $n'_p > 1.553$.

Referring to tables showing indices of refraction for various minerals, this fixes the feldspar as labradorite.

In selecting minerals for comparison, the selection of feldspar should be made with reference to a known section, such as a bisectrix. Any adjacent quartz grain may be selected, whether or not its chief axes of elasticity lie parallel with those of the feldspar grain. The value of those directions which do lie parallel to the chief axes of elasticity of the feldspar can easily be reckoned.

*Method for Determining feldspar and other Minerals through their double refraction by means of Michel Levy's Comparateur.**

First correct the scale of the comparateur, which can not be accurately made, so that 0 of the scale corresponds exactly to the thickness 0 of the quartz wedge of the comparateur. Do this with the teinte sensible plate. Insert the plate in the microscope below, and by shoving along the quartz wedge of the comparateur equalize successively the teintes sensibles of the first and second orders on the wedge, and read on the scale. Let these two readings be 375 and 720, symbolized by t and t' In thin sections dispersion may be neglected. It is known that t (375 in this case) corresponds to a retardation of the light waves of 0.000575mm. and t' (in this case 720) to one of 0.001128mm. Therefore the division of the scale taken as unit in the measurement (in above case the smallest division of the vernier, symbolized by d) equals $d = \frac{1128-575}{t'-t}$ in millionths of millimeter. In the above case $d = \frac{1128-575}{720-375} = 1.6087$ in millionths of millimeter, or 0.0000016 millimeter retardation of light wave in the thickness of the quartz wedge,

* MICHEL LEVY *Mineraux des Roches*, p. 34, etc.

corresponding to the movement of one division of the vernier.

Supposing the wedge thinned to o, and calling this reading T, we deduce the formula $T = \frac{1128t - 575t'}{1128 - 575}$. In the above case T = 16.27; this is therefore the correction, and to be deducted from the readings, to obtain their actual value.

A given reading on the scale may be called t". Then e"X= (t"—T)d, when e symbolizes the thickness of the mineral and X the index of double refraction ($n_g - n_p$ or $\omega - \varepsilon$).

It is evident that to use this method directly one must know e to find X, or vice versa. The direct methods of measuring e are inaccurate, therefore in practice a method of comparison with a known e is used. In the same section with the mineral to be determined, a known mineral is selected, preferably quartz parallel to the vertical axis. It is known that in quartz X ($n_g - n_p = \omega - \varepsilon$) =.00915. The interference colors of the quartz and of the mineral to be determined are read, and corrected by T. Then for the mineral studied eX = A; for the quartz eX' = A'. From this follows $X = \frac{A}{A'} X'$ or $X = \frac{A}{A'}$ (.00915)).

If the colors are too high or too low to be distinct, use a teinte sensible quartz plate; if the colors are too low, add the teinte sensible (like axes parallel); if too low, subtract (like axes crossed), then add to or substract from the reading, the value of the teinte sensible on the scale, as previously determined and corrected by T. For example, the teinte sensible alone reads 370. This minus T(= 16) = 354. If a feldspar or other mineral with low refraction colors is to be measured, add the teinte sensible, and read the graduation on the scale, which graduation corresponds to the sum of the colors. Say e.g., this is 590: correct by T. 590—T=574. Subtract the value of the teinte sensible, 574—354=220. Above formula then becomes $X = \frac{220}{A'}$ .00915. For too high colors subtract the teinte sensible.

Table of Single and Double Refraction for Feldspar Species, with Quartz and Common Green Hornblende.*

MINERALS.	PRINCIPAL INDICES OF REFRACTION. (Yellow Light.)			DOUBLE REFRACTION OF PRINCIPAL SECTIONS.		
	γ (n_g)	β (n_m)	α (n_p)	Plane of optic axes $\gamma - \alpha$ ($n_g - n_p$)	Plane perp. to α (n_p) $\gamma - \beta$ ($n_g - n_m$)	Plane perp. to γ (n_g) $\beta - \alpha$ ($n_m - n_p$)
Orthoclase	1.526	1.524	1.519	0.007	0.002	0.005
Microcline	1.529	1.526	1.523	0.006 to 0.007	0.003	0.003
Anorthoclase	1.530	1.529	1.523	0.007	0.001	0.006
Albite	1.540	1.534	1.532	0.008	0.006	0.002
Oligoclase	1.542	1.538	1.534	0.008	0.004	0.004
Andesine	1.556	1.553	1.549	0.007	0.003	0.004
Labradorite	1.562	1.557	1.554	0.008	0.005	0.003
Anorthite	1.562	1.557	1.554	0.013	0.007	0.008
Common green Hornblende	1.653	1.642	1.629	0.024	0.011	0.013
Quartz	1.553 (ϵ)	.....	1.544 (ω)	0.009 (ϵ-ω)	.....	.....
Canada Balsam	.....	1.539	.....	.....	.....	.....

*Adapted from Michel-Lévy and Lacroix; Tableaux des Minéraux des Roches, Paris, 1889.

Methods for Determining Feldspars by Ascertaining the Position of the Optic Axes.

These methods are among the most practical and accurate. It is well known that in feldspars the position of the optic axes varies regularly in regard to the crystallographic boundaries according to the change of chemical composition, and it is only necessary, therefore, to define the relation of the axes to these boundaries to determine the feldspar.

Michel Levy's Method.—This method, with more or less variation, has been lately much used in this country. In its original form, as proposed by the great French mineralogist, it may be described briefly as follows:

For this method feldspars must be twinned. If twinned after the albite law, find a section in the zone of symmetry, or nearly so. This zone is characterized by having the extinction angle in the two individuals on both sides of the twinning plane the same. If the angle of the position of equal illumination of the two individuals with the twinning line is greater than that of the position of extinction with the same line, the feldspar is more acid than oligoclase; if more basic, the reverse.

If the feldspar is twinned after both albite and Carlsbad laws, discover this by bringing the albite lamellæ in position of equal illumination—then the Carlsbad twinning will still show its differences of extinction. Find such a crystal in the zone of symmetry or nearly so, by the above method. Read the extinction angle on one side of the Carlsbad twinning plane and then on the other. Suppose these are 38° and 21°. Refer to Michel Levy's plates.* The vertical red line is the projection of the zone of symmetry. On the upper half of the projection the red figures equal + angles of extinction on the zone of symmetry; on the lower half the black ones equal — angles on the same zone. In Carlsbad twinning the two individuals are turned on vertical twinning axes 180°, so that the negative parts of one individual become side by side with the positive parts of another. Therefore, the two angles read on the two sides of the twinning plane correspond to the positive and the negative readings. They must be sought on the upper half and

* A thorough article on this subject, with reproductions of the diagrams of Michel Levy has been published by PROFESSOR N. H. WINCHELL, this journal, vol. xxi, No. 1.

the lower half respectively of the vertical line which is the projection of the zone of symmetry. In ordinary sections, it is impossible to determine which reading is positive and which negative, but the two readings are conjugated with respect to the center of the projections—that is, appear at equal distances from the center. Therefore the projection is sought out in which the two readings have the necessary conjugation —in the above case the figures point to labradorite Ab_3 An_4.

If a section is not cut exactly in the zone of symmetry, the angles on each side of the albite twinning line will vary, and their values will be at equal distances to the right and left of the vertical line, the distance varying with the deviation from the zone of symmetry.

Fouque Method—Find a bisectrix in convergent light and determine its optical character. To do this first bring the section into the position of extinction, when a cross is formed. Next, rotate the stage 45°, noticing the direction in which the hyperbolæ move out of the field, and bring the line joining the apices of the curves into the 45° position in diagonally opposite quadrants of the field. In this position determine by means of the quartz wedge, teinte sensible, or gypsum plate, whether this line is of greater or less elasticity than the bisectrix perpendicular to which the section is cut. The quartz wedge is ordinarily the most convenient means, and in using it remember that when like axes are superposed the colors of the section rise, and that when they are crossed the colors fall. If the line joining the hyperbolæ, which lies in the plane of the optic axes, is the direction of greatest elasticity in the section (a) then the section is cut perpendicular to a positive bisectrix. If this direction is that of least elasticity (c) the bisectrix is negative. Now bring the trace of the optic axes into position parallel with one of the cross-hairs and measure the angles by the method stated below. It is often convenient to remember that the positive bisectrix always emerges upon the brachypinacoid. If the bisectrix is positive, measure the angle between it and the trace of the basal plane. This may be recognized in the section as a crystal boundary or as a cleavage. If these are not present the angle may be measured against the pericline twinning planes, but in this case it is necessary to remember that this twinning plane is usually not exactly

Determination of the Feldspars According to Fouqué.

SPECIES OF FELDSPAR.	Specific Gravity.	Percentage of Silica.	Angle of the base (001, P) with a section perpendicular to the positive bisectrix.	The axial angle measured in air.	Character of the acute bisectrix.	Dispersion of the axes in a section perpendicular to the negative bisectrix (⊥ a).	The extinction angle on the section perpendicular to the negative bisectrix, between the trace of the plane of the optic axes and the trace of the intersection of the brachypinacoid (010, M) is	The extinction angle on the section perpendicular to the positive bisectrix, between the trace of the plane of the optic axes and the trace of the intersection of the base (001, P) is	Mean index refraction.	Angle of extinction with the trace of the intersection of the brachypinacoid, on sections parallel to the base (001, P)†	Angle of extinction with the trace of the intersection of the base on sections parallel to the brachypinacoid (010, M)†
Anorthite.....	2.745	44	35°	77½°	−	$\rho < v$*	55° 30′	48°	1.582	−36½°	−41½°
Bytownite.....	2.725	44	35°	77½°	−	$\rho < v$	57°	42°	1.582	−36½°	−41½°
Labrador-bytownite....	2.705	54	49° 30′	77°	+	$\rho < v$	58° 30′	33°	1.563	−11°	−25°
Labradorite.....	2.696	55	53°	77°	+	$\rho < v$	60°	22°	1.558	− 5½°	−20°
Andesine.....	2.675	58	68°	88°	+ −	$\rho > v$	66°	9°	1.553	− 2½°	−10°
Andesine-oligoclase.....	2.654	62	74°	86°	−	$\rho > v$	75°	3°	1.553	− 2°	− 4°
Oligoclase.....	2.645	64	74°	88°	−	$\rho > v$	88°	5°	1.542	+ 2°	+ 8°
Oligoclase-albite	2.640	65	87°	88½°	+	$\rho > v$	84° 30′	10° 30°	1.542	+ 2½°	+10½°
Albite	2.610	68	78°	77°	+	$\rho > v$	74°	19° 30′	1.534	+ 4°	+19½°
Anorthoclase....	2.580	68	78°	45°	−	$\rho > v$	88° 30′	9°	1.528	+ 2°	+ 9°
Microcline-anorthoclase	2.570	68	78°	60°	−	$\rho > v$	88° 30′	7°	1.528	+ 2°	+ 9°
Microcline.....	2.560	65.5	81°	88°	−	$\rho > v$	88°	10°	1.526	+15½°	+ 5½°
Orthoclase.....	.....	.....	.....	.....	−	.....	90°	3° to 7°	1.5237	0°	3° to 7°

* Signifying that optic angle for red is less than that for violet.

† Determinable on cleavage pieces.

parallel to the base, but varies from it according to the different species, by an angle which must be added or subtracted from the reading, according to the case, to get the true angle with the base.

If the bisectrix is negative, determine the angle between the trace of the optic plane and that of the brachypinacoid. The latter may be represented in a section either by a crystal edge, by a brachypinacoidal cleavage or by twinning planes of the albite or Carlsbad laws.

In either case find the angles corresponding to the species in the accompanying tables.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

State Geological Survey of North Dakota. Second Biennial Report. FRANK A. WILDER, State Geologist. Pages 262; with 39 plates, 21 figures in the text, and two folded maps. Bismarck, December, 1902.

This survey was begun in the year 1899, under the direction of professor E. J. Babcock, professor of chemistry and dean of the College of Mines in the University of North Dakota, at Grand Forks, with a very small appropriation from the state. His report on the general topographic and geologic features of the state, and on its clays of economic value, lignite, and water resources, in 103 pages, was the first biennial report of this survey, published in the early part of 1901. With the appointment of Mr. Wilder as professor of geology in the university, the direction of the state survey was transferred to him; and, in co-operation with the U. S. Geological Survey, he has been enabled to enlarge the scope of this work.

About two-thirds of this report are descriptions and discussions of the valuable lignite coal deposits which occupy the western half of the state, with the Turtle mountains as an outlying area farther east. Professor Wilder was assisted by Mr. L. H. Wood in this part of his work. The lignite beds, in their workable development, are restricted to the Laramie series of clays and sandstones; and the seams of lignite vary in thickness from an inch to forty feet. Many seams are often found in the same vertical section, and some of them are traced five or six miles, or more, as in the bluffs of the Little Missouri river; but generally they vary greatly in thickness within such distances, and frequently are of much less extent, thinning out entirely, and giving place to new seams a little higher or lower. Along the Northern Pacific railway in the region of Dickinson, Medora, and Sentinel Butte, and thence for

forty or fifty miles southward, lignite beds fifteen feet thick are not uncommon, and some extensive seams are twenty-five feet thick.

During the year 1902 the output of North Dakota lignite coal was 296,800 tons, with a value, at the mines, of $407,000, being more than twice the amount and value of its production in the year 1900.

Professor Babcock contributes as the final part of this report, an important paper of forty-three pages, on the "Water Resources of the Devil's Lake Region." It is found that this lake during the last twenty years has ranged from four to nine feet lower than it was in 1883; and its ancient high shore lines are twenty to thirty feet above the present water level. The greatest depth of water now found by soundings, in the central part of the main lake, is twenty-nine feet.

Thus the alkaline Devil's lake, so called in translation of its Sioux name, probably alluding to the bitterness of its water, which is the largest lake of North Dakota, about thirty-two miles long, with a very irregular area, has now no more than a sixth or an eighth so much volume as immediately after the retreat of the ice-sheet from this area, when, as an enlarged expanse of fresh water, it reached east into the basin of Stump lake, and thence outflowed southward to the Sheyenne river. W. U.

The Cause of the Glacial Period, being a Resume and Discussion of the Current Theories to account for the Phenomena of the Drift, with a New Theory by the Author. By H. L. TRUE, M.D., Member of the Ohio State Academy of Science. Pages xi, 162; with 7 plates, and 9 figures in the text. Cincinnati. The Robert Clarke Co., December, 1902.

The various theories which attribute continental glaciation to changes in the astronomic relations of the earth, as advocated by Croll, Ball, Drayson, Becker, and others, are reviewed and discarded by Dr. True; and the usual theories appealing to geographic changes, as great elevation of the lands that became enveloped by snow and ice, held by Lyell, Dana, LeConte, Upham, Very, Wallace, Wright, and others, are also considered insufficient or improbable.

Variations in the amount of heat received from the sun, or in its retention by the earth's atmosphere, with changes in the proportions of water vapor and of carbon dioxide in the air, as recently proposed by Arrhenius and Chamberlin to account for the Glacial period, are also thought to be inapplicable to this problem.

Instead of all these rejected hypotheses, Dr. True advances one original with himself; which, however, agrees with the view presented by Upham, in an appendix of Wright's "Ice Age in North America," by associating the glaciation of continental areas with the very extraordinary crumpling of the earth's crust and upheavals of mountain ranges which have characterized Late Tertiary and Quaternary time.

The new theory is stated as follows: "Up to and during the principal part of the Tertiary period the earth had so far cooled and the rocky crust had become so thickened that it sustained the pressure of

the arch for a long time, but finally the point was reached when it could sustain it no longer. 'The last grain of sand broke the camel's back.' The arch gave way or crumpled into the form of mountains, and as the crust was thicker at this time than any time previous, so were the upheavals in the form of mountains greater than any that had preceded them, and of course the troughs formed from the settling of the arch would be greater; thus the beds of the oceans settled down, forming deeper basins, thereby draining the polar regions and leaving them above water (especially was this the case around the North Pole), depriving them of their warm ocean currents, or water covering, and allowing them to cool off and begin to form ice caps. The warm climate of the Tertiary period continued until the settling process had so far drained the polar regions as to allow ice to begin to form when the climate began to change, which change continued until the Tertiary merged into the Quaternary. Thus began the formation of ice which finally culminated in a Glacial period. The conditions present were these: A land foundation around the poles for ice to rest upon. The circulation of the ocean shut off or confined to the regions south of the land barrier, but having free circulation within the tropical regions. The ocean thus confined would become warmer than it had previously been. If it had been carrying a certain amount of heat to be dissipated around the poles, and on account of the land barriers this heat were to be confined south of the polar regions, what would prevent the water from becoming warmer? Here we have a steaming ocean to furnish the vapor and a cold land surface to precipitate the snow, the conditions in perfection to produce a glacial period."

Dr. True proceeds further, to account for the geologically sudden and recent close of the Ice age, so far as it affected the now temperate latitudes, by introducing another grand cataclysm during the Champlain epoch. Here he supposes, as was suggested in 1866 by Sir John Evans, that, while the earth's axis probably remained unchanged in its direction, a comparatively thin crust of the earth may have slipped as a whole upon the much larger nucleal mass so that the locations of the poles upon the crust have been changed.

"North America and western Europe," says Dr. True, "moved down out of the cold region, while northern Siberia, on the opposite side of the earth, moved up into it. A slight and imperceptible movement in this direction had, no doubt, been going on for ages, as the load accumulated on one side of the earth, but at the time of which I am speaking something broke loose and precipitated a rush. A cataclysm was produced that submerged the North Atlantic region and southern part of the United States, and carried the earth beyond the point of equilibrium. Of course, the balance was finally established by the waters of the ocean, which, being free to move, rushed upon the land in the form of great tidal waves, which surged back and forth for a time, but finally settled down to a state of tranquility, while the diurnal revolutions of the earth went grandly on upon the old axis, with perhaps a slight break or variation from its usual regularity."

It is not probable that either geologists or physicists will approve this theory, which is a contribution by a layman to the already large number of attempts to explain the wonderful climatic changes causing and ending the Ice age. Like the carbon dioxide theory, it has a somewhat near relationship with the more simple explanation that has been advocated by the present reviewer, namely, elevation of continental areas as high plateaus above the snow line, and, when they became heavily loaded with ice-sheets, their depression beneath that weight, accounting for the Champlain epoch and the end of the Glacial period, excepting in the Arctic and Antarctic regions. W. U.

Existence du Cretace inferieur en Argolide Grece—Existence du Jurassique sup. et de l'infracretace dans l'isle de Crete—etc., etc., par L. CAYEUX [Comples Rendus de l'Academie des Sciences, Paris, 1903].

These are preliminary notes on observations made in Greece and the island of Crete on the Mesozoic rocks appearing in that part of the Mediterranean. The structure of the terranes in its overturned group is compared with that of the southern Tyrol. An interesting discovery is that of a radiolarian ooze in the Argolid which he thinks has affinities with radiolarians of the Neocomian in the Tyrol.

In Crete the composition of the beds is very varied, running from fine-grained calcareous sandstones to coralline limestones, clays, schist and jaspery beds; the fragmentary rocks take on the appearance of *flysch*. Several localities for fossils were found, brachiopods and corals predominating; there are also sea-urchins.

One note is given to a description of the rocks connected with volcanic eruptions of the Mesozoic time. Intrusive rocks predominate, and are both basic and acid. The author remarks that the "eruptive rocks metamorphosed the upper terranes among which they are included, and have left absolutely intact, the more recent terranes on which they repose" [as effusives].

He further remarks that the great quaternary subsidences of the Egean sea and this concomitant only represent the last episodes of the phenomena, the first manifestations of which go back to Jurassic times.

G. F. M.

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Utilization of iron and steel slags. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 221-232.)

ECKEL, E. C. (and C. W. HAYES.)

Iron ores of the Carterville district, Georgia. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 233-243.)

ECKEL, E. C.

Stoneware and brick clays of western Tennessee and N. W. Miss. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 382-392.)

ECKEL, E. C.

Salt and gypsum deposits of S. W. Virginia. (U. S. G. S. Bull No. 213, Ser. A, 1902, 406-417.)

ECKEL, E. C.

The white phosphates of Decatur Co., Tenn. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 424-426.)

ECKEL, E. C. (and C. W. HAYES.)

Occurrence and development of ocher deposits in the Cartersville district, Georgia. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 427-433.)

ECKEL, E. C.

Gold and Pyrite deposits, Dahlonega district, Georgia. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 57-64.)

ELDRIDGE, GEO. H.

Origin and distribution of asphalt and bituminous rock deposits in the United States. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 296-306.)

ELDRIDGE, GEO. H.

The petroleum fields of California. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 306-322.)

EMMONS, S. F.

Platinum in copper ores in Wyoming. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 94-98.

EMMONS, S. F. (and C. W. HAYES).

Contributions to Economic Geology, 1902. (U. S. G. S. Bull. No. 213, Ser. A, Economic Geol. 24.)

FENNEMAN, N. M.

The Boulder, Colo., oil field. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 322-333.)

FINLEY, GEO. I.

The Granite Area of Barre, Vt. Rep. of the Vermont State Geologist, pp. 59, 1902.)

FULLER, M. L.

Asphalt, oil and gas in S. W. Indiana. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 333-336.)

FULLER, M. L. (and GEO. H. ASHLEY.)

Recent work in the coal field of Indiana and Illinois. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 284-294.)

GERDINE, T. G. (and D. C. WITHERSPOON.)

Explorations among the Wrangall Mountains in Alaska. (Nat. Geographic Mag., vol. 14, No. 4, April, 1903, p. 161.)

GRABAU, A. W.

Studies in Gastropoda. (Am. Nat., vol. 36, No. 432, pp. 917-945, Dec., 1902.)

GRISWOLD, W. T.

Structural work in 1901 and 1902 in the eastern Ohio oil fields. (U. S. G. S. Bull. No. 213, Ser. A, pp. 336-345.)

HARRINGTON, B. J.

Composition of some Canadian Amphiboles. (Am. Jour. Sci., vol. 15, May, 1903, pp. 392-395.)

HAYES, C. W.

Manganese ores of the Cartersville district, Georgia. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 233-243.)

HAYES, C. W.

Coal fields of the United States. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 257-270.)

HAYES, C. W.

Oil fields of the Texas-Louisiana Gulf coastal plain. (U. S. G. S. Bull., No. 213, Ser. A, 1902, pp. 345-353.)

HAYES, C. W.

Asphalt deposits, Pike county, Ark. (U. S. G. S. Bull. No. 213. Ser. A, 1902, pp. 353-356.)

HAYES, C. W.

Origin and extent of the Tennessee white phosphates. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 418-424.)

HAYES, C. W. (and S. F. EMMONS.)

Contributions to Economic Geology. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 450.)

HILGARD, E. W.

Subterranean Water Supply of the San Bernardine Valley. (U. S. Dept. Agr., Report of Irrigation Investigations, pp. 103-145, 1901.)

HOBBS, W. H.

Tungsten Mining at Trumbull, Conn. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 98-99.)

KEITH, ARTHUR.

Iron ore deposits, Cranberry district, N. Carolina—Tennessee. (U. S. G. S. Bull. No. 213, Ser. A, pp. 243-247.)

KEITH, ARTHUR.

Tennessee Marbles. (U. S. G. S. Bull. No. 213, Ser. A, pp. 366-371.)

KEITH, ARTHUR.

Talc deposits of North Carolina. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 433-439.)

KEMP, J. F.

Igneous Rocks and circulating waters as factors in ore deposition. (Trans. Am. Inst. Inst. Min. Eng., Oct., 1902, pp. 16.)

KUMMEL, H. P.

Glacial Geology of New Jersey (Salisbury), vol. 5, Final Report of the State Geologist, pp. 802, pls. 66, Trenton, 1902.

LEE, W. T.

The Canyons of Northeastern New Mexico. (Jour. Geography, vol. 2, No. 2, Feb., 1903, pp. 22.)

LEITH, C. K.

Geologic work in the Lake Superior iron district during 1902. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 247-251.)

LINDGREN, WALDEMAR.

Neocene rivers of the Sierra Nevada. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 64-66.)

LINDGREN, WALDEMAR.

Mineral deposits of the Bitterroot Range and the Clearwater Mountains, Montana. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 66-71.)

LINDGREN, WALDEMAR.

Copper deposits at Clifton, Arizona. (U. S. G. S. Bull. No. 213, Ser. A, 1902, 133-141.)

MENDENHALL, W. C. (and F. C. SCHRADER.)

Copper deposits of the Mount Wrangell region, Alaska. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 141-143.)

MENDENHALL, W. C.

The Chistochina gold field, Alaska. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 71-76.)

RANSOME, F. L.

Copper deposits of Bisbee, Arizona. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 149-158.)

ROGERS, AUSTIN F.

Some new American species of Cyclus from the Coal Measures. (Contributions from the Geol. Dept., Col. Univ., vol. 10, No. 88.)

SALISBURY, R. D.

The Glacial Geology of New Jersey, vol. 5, Final Report of the State Geologist, pp. 802, pls. 66, Trenton, 1902.

SCHRADER, F. C. (and W. C. MENDENHALL).

Copper deposits of the Mt. Wrangell region, Alaska. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 141-149.)

SCHIMER, H. W.

Petrographic Description of the Dikes of Grand Isle, Vt. (Rep. State Geologist of Vermont, 1902, pp. 173-183.)

SMITH, W. S. TANGIER (and E. O. ULRICH).

Lead, zinc, and fluorspar deposits of western Kentucky. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 205-214.)

SMITH, W. S. TANGIER.

Lead and zinc deposits, Joplin district, Missouri-Kansas. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 197-205.)

SMITH, GEO. OTIS.

Gold mining in central Washington. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 76-81.)

SPENCER, A. C.

Manganese deposits of Santiago, Cuba. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 251-256.)

SPENCER, A. C.

Mineral resources of the Encampment copper region, Wyoming. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 158-163.)

SPENCER, A. C.

Reconnaissance examination copper deposits at Pearl, Colo. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 163-170.)

SPURR, J. EDW.

Ore deposits of Tonopah and neighboring districts, Nevada. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 81-88.)

ULRICH, E. O. (and W. S. TANGIER SMITH).

Lead, zinc, and fluorspar deposits of western Kentucky. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 205-214.)

VAUGHAN, T. WAYLAND.

Fuller's earth deposits of Florida and Georgia. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 392-400.)

WARD, H. A.

The Andover Meteorite. (Am. Jour. Sci., Vol. 15, Mar., 1903, pp. 395-397.)

WEED, W. H.

Gold mines of the Marysville district, Montana. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 88-90.)

WEED, W. H.

Tin deposits of El Paso, Texas. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 99-103.)

WEED, W. H.

Ore deposits at Butte, Montana. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 170-181.)

WEED, W. H.

Copper deposits of the Appalachian States. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 181-186.)

WEEKS, F. B.

Tungsten ore in eastern Nevada. (U. S. G. S. Bull. No. 213, Ser. A, 1902, p. 103.)

WHITEAVES, J. F.

Description of a New Species of Matheria from the Trenton Limestone at Ottawa. (Ottawa Naturalist, vol. 17, Apr., 1903.)

WINCHELL, H. V.

Amorphous Precipitates. (Eng. and Min. Jour., Vol. 75, No. 18, May, 1903, p. 661.)

WINCHELL, N. H.

The Pleistocene Geology of the Concannon Farm near Lansing, Kan. (Am. Geol., Vol. 31, May, 1903, pp. 263-309.)

WINCHELL, ALEXANDER N.

Note on Titaniferous Pyroxene. (Am. Geol., Vol. 31, May, 1903, pp. 309-311.)

WITHERSPOON, D. C. (and T. G. GERDINE).

Explorations among the Wrangall Mountains in Alaska. (Nat. Geographic Mag., vol. 14, No. 4, April, 1903, p. 161.)

WOLFF, J. E.

Zinc and manganese deposits of Franklin Furnace, N. J. (U. S. G. S. Bull. No. 213, Ser. A, 1902, pp. 214-218.)

WORTMAN, J. L.

Studies of Eocene Mammalia in the Marsh Collections. (Am. Jour. Sci., Vol. 15, May, 1903, pp. 399-414.)

CORRESPONDENCE.

THE ROCK NAME ANORTHOSYTE. By professor Cushing made aware of his article in THE AMERICAN GEOLOGIST, March, 1902, where also my name is mentioned, I should like to explain my views in regard to the term anorthosyte.

Cushing says, that the only objection urged against the name which has come under his notice and which seems to him to be valid, has been urged by me (Die Labradorfelse des westlichen Norwegens, I). I there argue that the name is equally applicable to an albite or oligoclase rock, and that these are too acid to be grouped with rocks, which are properly regarded as end series of the gabbro family. As such rocks are of the rarest kind, I agree, that my objection has most theoretical interest, but it has nevertheless its value.

In the Ekersund area, where I have examined the rocks exactly, I have described the special rocks under the names labradorite rocks and bytownite rocks, and it is still my opinion, that where the rocks have been exactly examined, it is best to apply these conciser names. In the Ekersund area most of the rocks were labradorite rocks, and therefore

the whole area has been described by me as a labradorite rock area, the same name as the earlier geologists have used.

For the purpose of mapping I agree with the American geologists, that it would be necessary to have a group name. And where it is desirable to have a group name, I cannot find that we have any better than anorthosyte, which long ago has been used by the Canadian geologists. And if I have proposed no substitute, it is because, I thought, that in spite of the objection above mentioned it might be desirable to have a practical group name, and then anorthosyte was the most fitting. To replace anorthosyte with plagioclasyte is not necessary. We should then have two names for the same rocks, and I think the petrographical nomenclature is rich enough before.

For my part I cannot use the name anorthosyte as title of my new paper "Die Labradorfelse des westlichen Norwegens II," but in the text I have called attention to the fact that these rocks might be called anorthosytes, because they consist both of labradorite rocks and andesine rocks. I have also used the name anorthosyte in my lectures because my studies of the plagioclase rocks in the areas of Ekersund, Bergen and Loften have shown that oligoclase, andesine and bytownite rocks occur together with the labradorite rocks. These studies have also convinced me, that the term anorthosyte has its value in the petrographical systematism as a group name for the leucocrate links of the gabbro and dioryte families correspondent to the pyroxenytes and other melanocrate rocks. And as we on a more exact examination divide the pyroxenytes in diallagytes, etc., we also have to divide the anorthosytes in oligoclase rocks, andesine rocks, etc.

The chemical and petrographical character of the different subdivisions of the anorthosytes is rather well known. The albite and anorthite rocks are very rare, and I have not seen any analysis of them. The chemical relation between the other subdivisions can be seen by the following analyses, especially of Norwegian rocks, which I know from my own examinations.

	I.	II.	III.	IV.
SiO_2	64.98	57.34	53.42	47.25
Al_2O_3...	19.50	25.32	28.36	31.56
Fe_2O_3...	2.51	1.10	1.80	....
FeO	0.30	0.04	....	2.29
MgO....	0.50	0.25	0.31	0.27
CaO	3.70	7.99	10.49	15.30
Na_2O....	6.09	5.37	4.82	2.52
K_2O.....	2.01	1.23	0.84	0.37

I. Oligoclase rock. Ostvaagö, Lofoten. (Kolderup: Lofotens og Vesteraalens gabbrobergarter. Mit einem Resumé in deutscher Sprache. Bergens Museums Narbog 1898).

II. Andesine rock. Fosse, Bergen. Will be published in my new paper. Die Labradorfelse des westlichen Norwegens II.

III. Labradorite rock. Ogne, Ekersund. (Kolderup: Die Labradorfelse des westlichen Norwegens. Bergens Museums Narbog 1896).

IV. Bytownite rock. Beaver bay, Minnesota. (R. Irving: Copper-Bearing Rocks of Minnesota). CARL FRED KOLDERUP.

PERSONAL AND SCIENTIFIC NEWS.

PROFESSOR T. C. CHAMBERLIN delivered a lecture on "The nebular hypothesis" at Northwestern University on April 29th.

HORACE V. WINCHELL will examine, the coming summer, the reputed copper districts of Alaska, entering the country by way of Valdes.

PROFESSOR RUSSELL D. GEORGE, of the State University of Iowa, has accepted the professorship of geology in the State University of Colorado.

DR. C. P. BERKEY, assistant professor of geology and mineralogy at the State University of Minnesota, has accepted an appointment to a similar position in Columbia University, New York, beginning in September.

PROFESSOR N. H. WINCHELL is making geological economic explorations in the vicinity of Flathead lake, Montana, and is likely to be absent from Minneapolis the greater part of the summer.

MR. ERNEST F. BURCHARD, at present teaching chemistry and geology in the Sioux City high school, has been appointed to a fellowship in geology at Northwestern University, from which institution he obtained his bachelor's degree three years ago.

ALBERT HUNTINGTON CHESTER, curator of the geological museum and professor of chemistry and mineralogy at Rutgers College, New Brunswick, N. J., died on April 13 from pneumonia. He was a graduate of Union College, and at one time taught at Hamilton.

GEOLOGICAL EXCURSION TO DEVILS LAKE AND THE DALLES OF THE WISCONSIN. On April 16th, 17th and 18th Professor C. R. Van Hise conducted a party of about seventy-five students from the University of Wisconsin and from Northwestern University to these localities.

MR. BAILEY WILLIS has accepted the position of leader of the Carnegie Geological Expedition to China, which has as its object the investigation of the Cambrian of that country. He will be assisted by Mr. Eliot Blackwelder of the University of Chicago. Mr. Willis expects to leave Washington in July, to attend the International Congress of Geologists at Vienna, and to go to China via Siberia.

DR. H. FOSTER BAIN has accepted an appointment as geologist on the United States Geological Survey, and during Mr. Bailey Willis's absence in China Dr. Bain will be acting editor of geologic folios. He is to take up the study of the lead and

zinc deposits of the Mississippi valley, and during the coming summer will make special investigations concerning these deposits in southern and northwestern Illinois.

PROPOSED TOPOGRAPHICAL MAP OF MICHIGAN. The late meeting of the Michigan Academy of Science took action looking to the completion of the topographical map of Michigan. In his presidential address professor I. C. Russell reviewed the subject and suggested united effort. The state survey is to co-operate with the United States Geological Survey. In addition to present funds available the state is asked to appropriate $1000 per year.

AT THE NEW MEXICO SCHOOL OF MINES the work of mining engineering will be specialized along three distinct lines. These are the mechanical, the metallurgical and the geological. The last mentioned will form a somewhat new departure in this country and will be known as the special course in Geology of Mineral Deposits. It will be under the direct supervision of president Keyes. There will be four instructors in the geological department of this institution.

IN THE NEW MEXICO SCHOOL OF MINES, six new professorships have lately been provided for. These chairs will be filled during the summer. The departments thus established are Mineralogy and Petrography, Mining, Mechanical Engineering, Metallurgy, Physics and Electrical Engineering, and Languages. Several special lectureships and associate professorships have also been established. Particular emphasis is placed on the lectureship and study of Mining Law.

THE MOST IMPORTANT PROBLEM in the manufacture of the peat into a commercial article is the economical removal of the moisture. This is now done by drying. After this process the peat is pressed into small bricks. The manufactured product must be kept dry, otherwise it becomes valueless for heating purposes. The cost of manufacture is from $1.50 to $2.00 a ton, and the cost of selling about the same. This means that the product will sell for from $3 to $4 a ton, and must find its market in competition with anthracite coal.

GEOLOGICAL EXCURSION TO THE LAKE SUPERIOR DISTRICT. Professor C. K. Leith, of the University of Wisconsin, conducted a party of students and geologists to the Vermilion, Mesabi, Gogebic and Marquette iron ranges and also to the copper region of Keweenaw point for a ten days' excursion (April 20th to 28th). There were present fifteen students from the University of Wisconsin, one from Northwestern University and one from the University of Chicago; also the following geologists: F. D. Adams, A. E. Barlow, J. M. Clements, U. S. Grant, W. H. Hobbs, C. K. Leith, A. P. Low, A. E. Seaman, C. E. Wright and F. E. Wright; also Kirby Thomas of West Superior and T. B. Caldwell of Lanark, Ontario.

DEPARTMENT OF GEOLOGY AT THE UNIVERSITY OF WISCONSIN. Professor C. R. Van Hise, who has been at the head of this department for some years, was elected president of the university on April 21st. His new duties begin about October 1st; in the meantime he is expecting to visit Europe and attend the International Congress of Geologists at Vienna. Dr. C. K. Leith has been promoted from assistant professor to professor of structural and economic geology. Dr. Wm. H. Hobbs continues as professor of mineralogy and petrology. Dr. J. Morgan Clements has resigned his professorship and will probably open an office as consulting economic geologist in New York City. Dr. N. M. Fenneman, of the University of Colorado, has been elected professor of general and physiographic geology.

THE COMPLETION OF THE PALEONTOLOGIC MONOGRAPHS begun by the late O. C. Marsh has been entrusted to professor Henry Fairfield Osborn, vertebrate paleontologist of the United States Geological Survey. The materials left by professor Marsh did not include any completed manuscript, but consisted chiefly of a series of fine lithographic plates and wood engravings, illustrating four important groups of vertebrates. The specimens illustrated are contained in part in the collections of the Survey and in part in those made for the Yale University Museum under the direction of professor Marsh. In order to insure the completion of these monographs within a reasonable period, professor Osborn recommended to the Director of the Survey a division of authorship, assigning the monograph on the Ceratopsia to Dr. J. B. Hatcher, now connected with the Carnegie Museum, Pittsburg, and that on the Stegosauria to Dr. F. A. Lucas, of the United States National Museum. Professor Osborn has himself undertaken the preparation of the monographs on the Titanotheres or Brontotheriidæ and on the amphibious dinosaurs of the order Sauropoda.

UNITED STATES GEOLOGICAL SURVEY. The mineral resources of the Mount Wrangell district in Alaska will be discussed in Professional Papers No. 15 by Messrs. W. C. Mendenhall and F. C. Schrader. This report is now in press. The chief mineral resources of the district are copper, gold and coal.

Dr. H. E. Gregory, of Yale University, has undertaken an investigation of the underground waters of Connecticut.

A topographic map of the country adjacent to the Randsburg and Johannesburg districts of California will soon be issued. The district is a desert area, and its mineral wealth consists of gold.

Hydrologic work consisting of the investigation of underground waters, has recently been begun in Michigan. Mr. W. F. Cooper, working under the supervision of Dr. A. C. Lane, state geologist, has charge of the work.

Messrs. G. F. Becker, S. F. Emmons, and C. R. Van Hise have been appointed delegates to the International Congress of Geologists at Vienna.

Dr. Arthur C. Spencer is to spend the present field season in Alaska, investigating the geology of Douglas island and making a special study of the ore deposits of the Treadwell mine.

AMERICAN INSTITUTE OF MINING ENGINEERS. The meeting of the Institute arranged for July in British Columbia, with an excursion to Alaska, will not be held.

The library of the Institute, located at the secretary's office, No. 99 John street, New York City, comprises about 10,000 volumes, having been recently enriched by the deposit of the books of R. W. Raymond and of the libraries of the late Clarence King and R. P. Rothwell. These volumes, combined with the large list of technical papers and government reports owned by the Institute, make a very valuable collection of literature on geology, mining, metallurgy and the allied arts. It is felt that the library, already possessing such a fine nucleus, should be made a complete reference library for the profession, and with that end in view it is proposed to raise a fund of $25,000 for the acquisition of additional books and for proper cataloguing. If a sufficient amount is raised, it will be possible to publish and forward to members of the Institute a complete classified index of the library and to engage a librarian competent to hunt up and abstract reports for members. This will be of special service to engineers remote from libraries. The important libraries of the late Clarence King and R. P. Rothwell, above mentioned, have been secured through the generosity of Mr. John Hays Hammond, and at his request will be known as the "Raymond memorial library."

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY. The geological work of the survey for the coming summer will be along the following lines:

1. Dr. Samuel Weidman, assisted by Mr. W. D. Smith of the University of Wisconsin, is to spend the earlier part of the season in a study of the district about Baraboo where recent developments have shown the existence of deposits of hematite in a slate or iron-bearing formation which overlies the Baraboo quartzite.

2. Later in the season Messrs. Weidman and Smith will return to the area of crystalline rocks in the north-central part of the state (vicinity of Wausau) with the expectation of completing the work in this district for a report on the general geology and also on the glacial features.

3. Professor U. S. Grant of Northwestern University will continue work in the lead and zinc district of the southwestern corner of the state, a preliminary report on which has just been published (Bulletin No. IX). He will be assisted by Messrs.

E. F. Burchard, E. E. Ellis and M. J. Perdue, of Northwestern University, and E. T. Hancock, of the University of Wisconsin. During the summer it is expected that detailed large scale topographic and geologic maps will be made of some of the more important mining centers.

4. Investigations on the clays of the state will also be carried on. A report on highway construction in the state (Bulletin No. X) written by Dr. E. R. Buckley, now state geologist of Missouri, has been recently published.

THE INTERNATIONAL CONGRESS OF GEOLOGISTS will hold its ninth session, Aug. 20 to 27th, 1903, inclusive, in the city of Vienna. The executive committee has chosen Mr. Max v. Gutmann, professor of mines at Vienna, as treasurer in place of Mr. F. Karrer, resigned.

The membership being limited the committee appeals to geologists and others, in every land, who are especially interested in geological subjects to attend the sessions so far as possible.

The membership fee for this session has been fixed at twenty-one francs. This sum should be sent to professor Max von Gutmann, Kantgasse, Vienna, Austria. Those desiring to take part in the Congress, who shall have sent the registration fee will receive a certificate of membership and, later, the published transactions of the session.

In making the program the committee has consulted leading scientists in Europe and America and believe that the papers and the discussions thereon will modify some current ideas upon the great problems of geological science.

Excursions.—The committee offers some fourteen different excursions to take place either preceding or immediately following the session. Each of these will be under the guidance of a noted specialist in the field chosen.

Those who desire to participate in these excursions are urged to send their names as soon as possible so that the committee can make necessary arrangements for their comfort.

The Geological Society of Hungary sends out a special invitation circular to the members of the congress to visit Budapest and the Danube. The excursion given on the lower Danube will be limited to 100 persons. Those desiring to take this excursion should make application before June 15 to the general secretary, C. Diener, Vienna, Austria.

THE NATIONAL ACADEMY OF SCIENCES held its Annual spring meeting in the National Museum April 20 to 23.

Five new members were elected bringing the total up to ninety-two. These five were: Professor Thomas C. Chamberlain, University of Chicago, geologist; Professor William James, Harvard University, psychologist; Professor Arthur G. Webster, Clark University, Worcester, Mass., physicist;

Professor Horace L. Wells, Yale University, chemist; Professor Edward L. Mark, Harvard University, biologist.

Below is the list of papers read:

"An estimate of the weight of the skeleton in the Sauropoda, or in the Sauropodous Dinosaurs," Henry F. Osborn; "New characters of the skulls of Carnivorous and Herbivorous Dinosaurs," Henry F. Osborn; "Models illustrating the evolution of the Amblypoda, also of the Dinosaur *Diplodocus*, together with the theory as to the habits of the Sauropoda," Henry F. Osborn; "Radioactivity of Thorium minerals," Geo. F. Barker; "The Law of Catalysis in concentrated solutions," J. M. Crafts; "The standardization of thermometric measurements," J. M. Crafts; The Rumford Spectroheliograph of the Yerkes Observatory," George E. Hale; "The determination of standard right-ascensions free from the personal equation for star-magnitude" (with stereopticon illustrations), Lewis Boss; "On the semi-diurnal tide of the northern part of the Indian ocean," R. A. Harris, introduced by Cleveland Abbe; "The melting point of a simple glass," Arthur L. Day, introduced by G. F. Becker; Biographical memoir of J. E. Holbrook," Theodore Gill; "Biographical memoir of Matthew Carey Lea," George F. Barker; "Biographical memoir of Clarence King," S. F. Emmons; "Biographical memoir of A. A. Gould," Jeffries Wyman, read by W. H. Dall; "Biographical memoir of James E. Keeler," Charles S. Hastings; "The diffusion of vapor into nucleated air," Carl Barus; "Biographical memoir of Theodore Lyman," H. P. Bowditch; "The nomenclature of the topography of the bottom of the oceans," Alexander Agassiz.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting of May 6th the following program was presented: "Correlation of the Potomac Formation in Maryland and Virginia," Lester F. Ward; "Pocono Rocks in the Allegheny Valley," M. R. Campbell; "Age of the Mercer Group," David White. The special meeting of May 13th, 1903, was devoted to a consideration of "The Quantitative Classification of Igneous Rocks," continuing the discussion of the papers presented at the 140th meeting. An abstract of Dr. Mathews' paper is here given, which served as a basis for this discussion.

Abstract of Dr. E. B. Mathews' Criticism of the Quantitative Classification of Igneous Rocks.

I. *Strong points of the classification.*

1. Simplicity of the basal conceptions. There is no difficulty in grasping the basal conceptions which are applied with uniformity, and the rules for computation may be followed without the introduction of personal equation.

2. Sharpness of definition. The quantitative character of the classification produces sharpness in definition, leaves no excuses for ambiguity, and enforces exact use of terms. The

system is *expansive* for increasing refinement and yet the number of terms for a given rank or division is *limited.*

3. Nomenclature. This is particularly strong in such terms as salic, femic, etc., and in the mnemonic terminations indicating classes, ranks, etc.

4. Suggestive of new lines of investigation. The new grouping will stimulate a study of the model variations of a given form. It forces home the chemical composition and its mineralogical expression and emphasizes the complementary roles of rock-forming minerals. It will develop more careful descriptive work.

II. *Weak points in the classification.*

1. Nomenclature. There is little connection between the field terms proposed and those of the new classification and they are based in some degree on different principles. The roots chosen, while adaptable to the specialists of today, have little or no meaning or arrangement for the new student or layman in petrography.

2. Subordination of texture. The new classification lays too little stress on the textures, which are easily recognizable.

3. Previous literature is rendered unavailable for a number of years until it has been thoroughly reworked and rephrased.

4. Chemical analyses.

(a) Little can be told with certainty regarding the classificatory position from an inscription of a chemical analysis and no rock is surely placed without going through the entire computation.

(b) The increased refinement in the discrimination between bulk analyses surpasses the ability to discriminate types in the field. This leads possibly to incorrect geological and petrographical interpretations of rock bodies.

(c) The great expense involved in chemical analyses is likely to limit petrography to members of official organizations and men of means or leisure. The average petrographical worker of today among teachers can not command numerous high-class silicate analyses. (The use of slides removes in great measure this criticism.)

5. The five-fold division vitiates the underlying principle of the classification in that the rock may be classified on 37.6 of the contents disregarding 62.4 of the same. This difficulty is most manifest in the Salfemanes although the rocks known introduce few major difficulties.

III. *Conclusion.*

The new classification will not in itself supplant the present nomenclature, but will furnish a means of expressing concisely the chemical position of a given rock in much the same way as the scientific nomenclature of botany is related in the present popular terms.

INDEX TO VOL. XXXI.

A.

Alden, William C., 255.
Alkaline rocks, Madagascar, A. Lacroix, 183.
America, how long ago peopled, 312.
American Institute of Mining Engineers, 65, 397.
Ames knob, North Haven, Maine; a seaside note Bailey Willis, 159.
Ami, H. M. Sketch of the life and work o the late A. R. C. Selwyn, director of the Geological Survey of Canada, 1869-1894; 1; and bibliography, 16.
American Association for the Advancement of Science, 66.
Analyses en bloc et leur interpretation, M. F. Fouque, 181.
Anorthosyte, The rock name, C. F. Kolderup, 392.
Apatite crystals, Antwerp, N. Y., N. Knight, 62.
Ashley, George H., 255.

B.

Babcock, E. G., North Dakota Geological Survey, 383.
Bain, H. Foster, 128, 394.
Barrell, Joseph, 325.
Basin range structure in the Death Valley region of southeastern California, M. R. Campbell, 311.
Baue L. A., Magnetic declination tables, etc. 123.
Belly River beds of Canada, J. B. Hatcher, 369.
Berkey, C. P., 394.
Bison, extinct, from Alaska, 262.
Block mountains in New Mexico, D. W. Johnson, 135.
Bownocker, J. A., The central Ohio natural gas nelds, 218.
Burchard, Ernest F., 394.

C.

Calkins, F. C., Petrography of the John Day basin, 54.
Calvin, S. Iowa Geological Survey, 124.
Cambrian faunas, G. F. Matthew, 256.
Campbell, M. R. 255; Basin-range structure in the Death Valley region of southeastern California, 311.
Cause of the Glacial period, H. L. True, 384.
Cayeux, L., Mesozoic formations in Greece and Crete, 386.
Central Ohio natural gas fields, J. A. Bownocker, 218.
Ceratops beds, Lance Creek, Wyoming, J. B. Hatcher, 369.
Chamberlin, T. C., 193, 394; Pleistocene geology near Lansing, Kansas, 265.
Chester, Albert H., 394.
Chicago Academy of Science, 64.
Clapp, F. G., The marl-loess of the lower Wabash valley, 158.
Clark, W. B., Maryland Geological Survey, 54.
Clarke, John M., Annotations of Jaekel's theses on Orthoceras and other cephalopods, 216.
Clayton stone axe, 193.
Columbia University, fall excursions of he geological department, H. W Shimer, 62.
Concannon farm, Pleistocene geology of near Lansing, Kansas, N. H. Winchell, 263.
Condra, G. E., On Rhombopora lepidodendroides (Meek), 22; An old Platte channel, 361.
Cope, Edward D., catalogue of all the publications of, 1859-1897, P. Frazer, 180.
Correspondence.
Apatite crystals, Antwerp, N. Y., N. Knight, 62; Fall excursions of the geologica department, Columbia University H. W. Shimer, 62; The rock name anorthosyte, C. F. Kolderup, 392.
Crete, Jurassic and Cretaceous formations in, L. Cayeux, 386.
Curtis, George Carroll, Note on the West Indian eruptions of 1902, 40.
Cushing, H. P., Recent geologic work in Franklin and St. Lawrence counties, N. Y., 180.

D.

Dale, T. Nelson, Structural details in the Green Mountain region and in eastern New York, 58.
Davis, W. M., 262.
Death Valley region of southeastern California, basin-range structure in, M. R. Campbell, 311.
Determination of the feldspars in thin section, J. E. Spurr, 376.
Diamond mines of South Africa, 51.
Diller, J. S. Topographic development of the Klamath mountains, 257.

E.

Editorial Comment.
The diamond mines of South Africa, 51; A new building for the national museum at Washington, 178; How long ago was America peopled? 312.
Ellensburg (Washington) folio, geological atlas of U. S., G. O. Smith, 255.
Erratic Bowlder from the coal measures of Tennessee, S. W. McCallie, 46.
Feldspars, determination in thin section, J. E. Spurr, 376.
Fenneman, N. M., Lakes of southeastern Wisconsin, 185.
Foerste, Aug. F., The Richmond group along the western side of the Cincinnati anticline in Indiana and Kentucky, 333.

F.

Fouque, M. F., Les analyses en bloc et leur interpretation, 181.
Frazer, Persifor, Alphabetical cross-reference catalogue of all the publications of Edward D. Cope, 1859-1897, 180.
Fuller, M. L., The marl-loess of the lower Wabash valley, 158; Ditney folio, U. S. Geological Survey, 255.

G.

Gannett, Henry, The origin of certain place names in the United States, 186.
Gentil, Louis, Esquisse stratigraphique et petrographique du bassin de la Tafna (Algeria), 253.
Geological age of the West Indian volcanic formations, J. W. Spencer, 48.
Geological Society of America, 66, 128.
Geological Society of London, 129.
Geological Society of Washington, 64, 193, 325, 399.
Geology of the Jemez-Albuquerque region, New Mexico, A. B. Reagan, 67.
George, Russell D., 394.
Glacial geology of New Jersey, R. D. Salisbury, 316.
Glacial period, cause of, H. L. True, 384.
Glacier lakes in the Cleveland hills, P. F. Kendall, 124.
Grabau, Prof. A. W., 325.
Greece, Lower Cretaceous in, L. Cayeux, 386.
Gregory, H. E., 396.
Grönwell, K. A., Bornholms Paradoxidesslag og deres fauna, 186.

H

Hague, Arnold, 325.
Hall, Prof. Charles M., The life and work of, by W. Upham, 195.
Harris, Gilbert D., Report on the geology of Louisiana, 256.
Harris, Israel H., Collection of invertebrate fossils in the U. S. National Museum, C. Schuchert, 131.
Harvard University, field course in geology, 262, 326.
Hatcher, J. B., Relative age of the Lance Creek (Ceratops) beds of Converse county, Wyoming, the Judith River beds of Montana, and the Belly River beds of Canada, 369.
Hershey, Oscar H., Some evidence of two glacial stages in the Klamath mountains in California, 139; Structure of the southern portion of the Klamath mountains, 231.
Hovey, Dr. E. O., 193.
Huntington, Ellsworth, 326.

I.

Index animalium, C. D. Sherborn, 184.
International Congress of Geologists at Vienna, 397, 398.
Iowa Geological Survey, annual report, 124.

J.

Jaekel's theses on the mode of existence of Orthoceras and other cephalopods, R. Ruedemann, 199.
John Day basin, petrography, F. C. Calkins, 54.
Johnson, Douglas W., Block mountains in New Mexico, 135.
Judith River beds, J. B. Hatcher, 369.

K.

Kemp, James F., 193.
Kendall, P. F., Glacier lakes in the Cleveland hills, 124.
Klamath mountains, California, Oscar H. Hershey, 139, 231; topographic development, J. S. Diller, 257.
Knapp, George N., 316.
Knight, Nicholas, Apatite crystals, Antwerp, N. Y., 62.
Kolderup, C. F., The rock name anorthosyte, 392.
Kümmel, Henry B., Geological Survey of New Jersey, 316.

L.

Lacroix, A., Les roches volcaniques de la Martinique, 55; Les roches alcalines, Madagascar, 183.
Lance Creek (Ceratops) beds, J. B. Hatcher, 369.
Lakes of southeastern Wisconsin, N. M. Fenneman, 185.
Lansing, Kansas, Valley loess and the fossil man of, Warren Upham, 25; Pleistocene geology of the Concannon farm, near, N. H. Winchell, 263.
Leith, C. K., 395.
Leonard, A. G., Iowa Geological Survey, 124.

Louisiana. Report on geology, [illegible] Harris. 25a.

M.

M[illegible], E. W. [illegible] from the coal measures [illegible] 4.
Magnetic declination [illegible] Islands. 12[illegible]
Mammoth [illegible]
Manitou formation [illegible] Schuchert. 16
Marcellus [illegible] the lower [illegible] 23.
Martinsburg [illegible] 5.
Maryland Geological [illegible] Clark. 5.
Mathews, E. B. [illegible] classification of igneous rocks. 19
Matthew, [illegible] fauna. 26
Merrill, [illegible] from Mount [illegible] 12
[illegible]

[illegible]

Spencer, A. C., 397.
Spencer, J. W., Geological age of the West Indian volcanic formations, 48; 65.
Spurr, J. E., The determination of the feldspars in thin section, 376.
Structural details in the Green Mountain region and in eastern New York, T. Nelson Dale, 58.
Structure of the southern portion of the Klamath mountains, California, O. H. Hershey, 231.

T.

Timber lines, I, C. Russell, 121.
Tin in Alaska, 325.
Titaniferous pyroxene, A. N. Winchell, 309.
Todd, J. E., Pleistocene geology near Lansing, Kansas, 291.
Todd valley, an old Platte channel, G. E. Condra, 361.
True, H. L., The cause of the Glacial period, 384.

U.

Upham, Warren, Valley loess and the fossil man of Lansing, Kansas, 25; The life and work of Professor Charles M. Hall, 195.

V.

Valley loess and the fossil man of Lansing, Kansas, Warren Upham, 25.
Van Hise, C. R., 129, 324, 394, 395.
Vermont, Report of the state geologist, G. H. Perkins, 122.

W.

Wahner, F., Das Sonnwendgebirge im Unterinnthal, 185.
Washington state geological survey, 325.
West Indian eruptions of 1902, George C. Curtis, 40.
West Indian volcanic formations, J. W. Spencer, 48.
Whiteaves, J. F., 262.
Wilder, F. A., North Dakota Geological Survey, 383.
Willard, D. E., 192.
Willis, Bailey, Ames knob, North Haven, Maine, a seaside note, 159; expedition to China, 394.
Williston, S. W., 291, 371.
Winchell, Alexander N., Note on titaniferous pyroxene, 309.
Winchell, Horace V., 324, 394.
Winchell, N. H., Some results of the late Minnesota Geological Survey, 246; The Pleistocene geology or the Concannon farm, near Lansing, Kansas, 263; explorations in Montana, 394.
Wisconsin Academy of Science, Arts, and Letters, 129.
Wisconsin Geological and Natural History Survey, 397.
Wisconsin, University of, department of geology, 396.
Wright, G. F., Pleistocene geology near Lansing, Kansas, 294.

MAR 28 1939.